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APPLIED MECHANICS REVIEWS

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REVIEW OF PANEL FLUTTER AND EFFECTS OF AERODYNAMIC NOISE

PART II: STRUCTURAL EFFECTS OF AERODYNAMIC NOISE

by

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Related to but distinct from the problem of panel flutter discussed in Part I of this bibliographical review [AMR 13, Jan. 1960], a structural problem that has been of concern to design engineers in recent years is the fracture of secondary structures near the jet pipe and the failure of other parts downstream in close proximity to the jet exhaust. These failures are believed to have been caused by vibrations excited by the aerodynamic or jet noise. The pressure fluctuations due to turbulence in boundary layers and wakes behind the aerodynamic surfaces also appear to create similar situations.

In recent years the problem of jet noise has attracted the attention of many research workers both in this country and Great Britain. Research so far has concentrated on measuring the nature and magnitude of the noise field around the jets and on studying the mechanism of its generation. Based on this knowledge several noise suppression devices have been suggested and attempts have been made to estimate and to increase the fatigue life of the structural members exposed to this noise field.

The possible predominance of aerodynamic noise over other sources of noise generation at high Mach numbers was first pointed out by Fleming (1). Following reports of fatigue failure of secondary structures in the neighborhood of jet exhausts, the vibration of a large flat plate at various positions near the boundary of the jet was studied at the University of Southampton. Some of these results are discussed in (2). From the standpoint of structural fatigue it appears that frequency is often of more significance than amplitude, for a sound of even low intensity at the natural frequency of a structural panel will cause it to oscillate. The conventional remedy for this situation becomes awkward when the noise spectrum is a flat one containing all frequencies. This usual approach requires the designer to keep the natural frequencies of the structural components subject to the jet exhaust outside of the noise spectrum. This requirement may force the structure to be either weaker or heavier than is desirable from other design considerations. One obvious way of avoiding the noise problem appears to be to locate and space the jets so that no structural component lies in the vicinity of the jet exhaust. For example, a considerable noise decrease inside the prototype Caravelle Twin-Jet Airliner has been reported effected by locating the two engines at the rear of the fuselage (3).

The first analytical prediction of jet noise useful in structural vibration problems is due to Lighthill (27, 33). Miles makes use of this analysis in his analytical treatment of the buffeting of aircraft structures excited by the random noise of the jet exhaust (4, 5). Assuming the dynamic response of a panel to be dominated by one mode, the panel has been treated as having a single degree of freedom and has been analyzed by analogy with a lightly damped single-degree-of-freedom oscillator. This analysis possesses the distinguishing feature of relatively sharp selectivity associated with resonance, a characteristic of the dynamic response of a simple elastic system. The oscillator is supposed subjected to a random force at a point and, using spectral techniques, resonance is shown to be an essential factor in the fatigue failure of a panel subjected to jet buffeting. Using the normal distribution for the random function and a typical exponential relation between the number of stress reversals and the failure stress, it has been demonstrated that both Miner's rule of linear accumulation and Shanley's rule of quadratic accumulation of fatigue damage lead to equivalent stresses proportional to the root-mean-square stress. The mean square stress is shown to be proportional to (a) the natural frequency of the panel ω_0, (b) the noise spectral density at ω_0, (c) the square of the static stress per unit pressure S_0, and (d) the reciprocal of the damping of the panel, expressed as a fraction of critical damping δ. This theory is then applied to the buffeting of a panel by a jet for which Lighthill's theory of noise generation is valid. The results indicate how the stress, and consequently the probable time for fatigue failure, are affected by increasing the stiffness of the panel.

Some aspects of jet noise from the structural point of view have been discussed by Wolfe in a Symposium on Jet Efflux held in England at the College of Aeronautics, Cranfield, during 1956 (6). He refers to experimental investigations made to determine the characteristics of jet noise spectra which indicate that the spectrum is of a continuous nature, is free of marked peaks, and extends over wide ranges of frequencies. This spectrum appears to be less intense at higher frequencies. One way of increasing the fatigue life of a structure is to keep the induced stresses or, in turn, the amplitude of motion of the panel, as small as possible. Since it is only by vibrating that the panel can transmit sound, it may be inferred that the fac-

tors which influence the intensity of transmitted sound must also influence the amplitude of vibration of the panel. Consequently the transmission of sound has direct bearing on the fatigue life of the panel. Franklin (6) examines, in a qualitative manner, the problem of the transmission of sound through an infinite, elastically supported, thin panel at one side of which plane waves are arriving at normal incidence. Considering incident, reflected and refracted waves the equation of motion of the panel is set up and solved for the ratio of intensities of the incident and transmitted waves. This ratio for finite panels is found to be somewhat different from that for infinite panels, particularly at frequencies above that corresponding to the first resonance. The reasons for such behavior are discussed. Using Miles's analysis, the stresses are obtained for a panel vibrating in its fundamental mode (6d). The mean square value of the stress envelope is found to vary inversely as the fraction of critical damping and directly as the frequency and power spectral density at that frequency. The same procedure is used to find the stresses when the panel is vibrating in other modes and the total response is obtained by summation. The estimates thus obtained are found to be of the same order of magnitude as those measured on aircraft.

Different sources of structural damping and their effectiveness are discussed in (6c). To increase the damping at riveted and bolted joints (due to structural hysteresis) greater rivet slip or dynamic friction appears to be necessary. The use of inserts and damping tape are mentioned as effective ways of increasing damping. The effectiveness of the latter has been studied by exciting the structure of the Vickers Supermarine type 544 aircraft by a loudspeaker and recording the response of each structural item at the estimated position of maximum bending stress for its fundamental mode (6e). The endurance tests on a full-scale rear fuselage have indicated that damage at counter-sunk skin attachments, fatigue failure of certain internal stiffeners and, finally, severe cracking of the light trailing ribs in the tailplane follow in order. During discussion (6f), the lack of fatigue data at low stress levels produced by jet noise, the importance of selection of material by fatigue characteristics, and the need for internal damping were emphasized. Sandwich panel and honeycomb construction were found to withstand higher noise levels than the conventional stringer-type structure.

Structural fatigue under acoustic loading has recently been studied by employing high-speed destructive testing techniques. The use of a high-intensity siren for such a purpose has been described by Belcher (7). Reference (8) deals with the response of simple aircraft skin panel specimens subjected to random and discrete noise in the laboratory. The stress levels and fatigue life are compared for a panel exposed to random and to discrete noise.

An attempt is made in (9) to check experimentally some of the analytical results obtained by Miles. In these tests, flat panels were placed in the near-noise field of a 4-inch air jet at different axial and radial distances from it and the induced stresses in the panel were measured. The structural characteristics S_0, ω_0, and δ needed in the theoretical evaluation of stress were determined by exposing the panels to the periodic noise of a siren the noise intensity and fundamental frequency of which could be varied. The experimental results indicated a fairly good agreement with theory. Another check was made in another set of experiments in which the thickness of the panel was changed while other factors were maintained constant. The measured stresses were inversely proportional to the 3/2 power of the thickness, as predicted by theory. Further experimental verification of Miles's theory has been attempted in (10) in which the previous tests were extended to curved panels. The static and dynamic responses of these were obtained experimentally, and tentative conclusions regarding their nonlinear behavior drawn. A decrease of spring stiffness occurs when negative pressure is applied on the concave surface of the curved panel during static tests. The dynamic tests have indicated that the responses of flat and curved panels are similar and tend toward symmetry about the natural frequency at low-pressure inputs. At high input pressures they exhibit completely different kinds of nonlinearity. At the particular input level tested, an increase of stiffness with deflection in the case of flat panels and decrease of stiffness in the case of curved panels has been observed. In spite of this indicated difference in behavior, the theory seems to be in good agreement with experiment. Another point believed worth mentioning here is that most of these experiments were conducted at different locations of the turbojet noise field and were not simply laboratory tests.

A few exploratory tests of the fatigue of simple riveted panels under discrete-frequency noise are reported in (9, 10) and the manner of failure and the variation of fatigue life with intensity of the input noise are stated. A more complete description of experimental techniques used in references (9, 10) has been presented in (11). Additional tests of simple aluminum panels ranging in thickness from 0.032 inch to 0.081 inch are also reported. In the stress range of the tests, the combined structural and radiation damping of flat panels was found dependent on panel stress or deflection and not on panel thickness. At high stress levels a rapid increase in damping with stress is observed.

Comparisons of fatigue life of both flat and curved panels and cantilevered beams exposed to both random and discrete inputs are made in reference (12). The curvature of the panel (especially with pressure differential across it) increases the fatigue life greatly. The increase in thickness of the panel has a similar effect. The effect of method of mounting on fatigue life has been studied by using inserts at the riveted and bolted joints. Inserts on both sides of the panel at these fixtures nearly doubled the fatigue life of the panel. In all the tests failure started in the stiffener elements, hence care in the detail design of the supporting structure is to be emphasized. At a given root-mean-square stress level flat panels fail earlier under random jet noise than under discrete-frequency noise. This is particularly the case at low stress levels where the damping is relatively low; as stress level is increased the panel damping increases and the difference in fatigue life tends to be smaller. A similar result has been obtained with notched cantilevered beams subjected to random noise and to sinusoidal load at different stress levels. Miles's theory fits this data fairly well at low stress levels and is very conservative at the higher stress levels.

Kirchman et al (13) consider the response of thin elastic isotropic plates under sinusoidal acoustic excitation. Assuming that the aircraft panel behaves like a nonlinear spring, an analytical approach has been advanced to obtain the amplification factors for the resonant response of the panel. This theory checks (for the order of magnitude) with experimental results obtained by exposing square panels to sound pressure of 150 db, while the amplification factors calculated by the use of linear theory are approximately five times larger than the test results. Square panels up to lengths of side/thickness = 120 have exhibited such nonlinear behavior at the noise level tested. The edge fixity of the panel seems to be an important parameter.

The concepts of random vibration and spectral density statistical distribution have been experimentally studied on actual aircraft with turbojet engines (14). The statistical distribution of side-wall vibration is inferred to be not precisely of the Rayleigh type. A decrease in noise-induced vibration is noticed with increasing air speed or with a decrease of the relative velocity between the jet exhaust and the surrounding air. This is in agreement with the analytical prediction of jet

noise by Lighthill. A method of evaluating cumulative fatigue damage induced in structures due to intense sound fields by correlation with results of mechanical vibration tests has been suggested in reference (15).

Some detailed work dealing with the transmission of sound through thin rectangular plates excited by plane waves of high frequency on one side has been reported in references (16–19). In all these references the expressions for deflection are obtained and the energy transmission coefficient calculated in each case. Vogel (16) solves the acoustic problem of a simply supported elastic plate in a fluid medium. This work is extended in (17) to a thin rectangular elastic plate clamped in a rigid infinite baffle and separating two different fluid media. The same problem for a viscoelastic plate has been solved with simply-supported boundary conditions in reference (18) and with clamped boundary conditions in reference (19). The viscoelastic material is assumed to obey Maxwell's tri-axial linear stress-strain relations and the results obtained are compared with those for elastic plates. The restriction to plane impinging waves has been removed in (20) and scattering and transmission of sound waves of general form is studied. Once again the plate is assumed to separate two different fluid media and is elastic, rectangular in shape and simply-supported in a rigid infinite baffle.

The technique of damping vibrations of a panel by addition of damping tape has been discussed in (6c) and (6e). A quantitative analysis of the effectiveness of such a damping layer which is in good agreement with experimental results has been presented in reference (21).

An analytical study of the noise spectra radiated by thin, stiff, flat plates under the action of turbulent boundary layer pressure fluctuations is made in reference (22). Plate parameters which influence sound transmission and the dependence of transmitted power and spectrum shape on boundary-layer thickness and flow Mach number are discussed. Some possible methods of reducing noise transmission are briefly mentioned. The experimental data of pressure fluctuations in the turbulent boundary layer are conveniently used in (23) to calculate the flexural vibrations of a plate excited by such a boundary layer on one side. The sound field resulting from this vibration is also obtained.

Skin panels of an aircraft wing may also be excited by fluctuating pressures on its surface. Measurements of pressures on wing surfaces and wind-tunnel walls have indicated that the ratio of the fluctuating pressures to the dynamic pressure of the flow is independent of Mach number at subsonic speeds. The pressure fluctuations, in general, appear to increase with the Mach number of the flow. The presence of shock waves and separated flow adjacent to an aerodynamic surface is found to intensify the pressure fluctuations greatly.

The representation of a structure as a one-degree-of-freedom system and the assumption of input power as the power spectral density at the panel resonant frequency is, in effect, a highly simplified presentation of the real problem (4, 5). This simplification amounts to assuming, among other things, that the pressures on the whole area of the structure (panel) are in phase. Actually this is not the case and for the further improvement of the theory it becomes necessary to consider the spatial distribution of pressure over the surface. For more complicated structures or input both space and time correlations may become necessary in order to get further accuracy. Some work has been reported recently on the experimental determination of the spatial distribution of pressure. In (24) the application of correlation techniques to the determination of load distribution is discussed and the correlation measurements made in the near noise field of a full-scale turbojet engine are presented. The longitudinal and transverse cross-correlations for the pressure fluctuations on the wall adjacent to a fully developed turbulent boundary layer are given in (25).

MEASUREMENT AND THEORY OF JET NOISE

Aircraft noise arises from many sources. The propellers, mechanical units of the propulsion systems, the intake and exhaust of aircraft engines, the flow in boundary layers and in wakes of aircraft surfaces are among the sources which early attracted the attention of designers. A survey of noise estimates and of several suppression devices in use is available (26). Unlike noise from other sources, the noise arising from jet-engine exhaust seems to be serious both from the physiological and from the structural point of view. A first attempt at the analysis of such noise has been made by Lighthill (27). This significant work provides a basis for coordination of experimental results. Lighthill's theory introduces the concept of an "acoustic quadrupole" as the elementary sound generator. He finds the sound power radiated by a jet to be proportional to the eighth power of a typical velocity U and to the second power of a typical length l in the flow. An acoustic power coefficient K (K = acoustic power/$\zeta_0 U^8 a_0^{-8} l^2$, where ζ_0 = density, a_0 = sound velocity at ambient condition) and the efficiency η of aerodynamic sound production are obtained by dimensional analysis. The latter, η, is proportional to M^8 and is shown to increase with the convection speed of fluctuations. In view of its agreement with reliable information obtained from experimental data on cold jets (28-32), the general theory has been applied to the noise of jet engines (33). Results check with the directional distribution of the intensity of sound obtained experimentally. The prediction of proportionality of noise intensity to U^8 in the absence of convection effect is, however, in disagreement with experiment at the higher subsonic Mach numbers. For example, at stations perpendicular to the jet, where convection would be absent, the experimental results have indicated that noise intensity is proportional to $U^{6.5}$. This discrepancy is attributed to the possible presence of less turbulence at higher Mach numbers. Lighthill also finds that a given level of turbulence can generate more sound in the presence of mean shear and that this has a directional maximum at 45° to the shear layer.

Proudman (34) has calculated approximately the acoustic power output from isotropic turbulence using the general theory of Lighthill. He finds that at large Reynolds numbers the main contribution to the power output comes from the larger, non-dissipating eddies. The lower frequency sound from the fully turbulent core of the jet, farther downstream, can be estimated from this theory.

Lighthill's theory is valid for subsonic flows only. A theory of the noise of supersonic jets has been developed by Powell (30). According to this theory, under "favorable" conditions, the shock pattern in the jet is such that a mechanism analogous to that of edge tones will develop and greatly amplify the sound produced.

Reference (2) deals with an exhaustive survey of the jet noise work carried out by universities and research organizations, with special reference to an understanding of the basic phenomenon. A photographic examination of circular and two-dimensional jets has led Powell (35) to the argument that the sound is formed by the interference of eddies moving downstream with the standing shock waves in the supersonic stream. The mathematical analysis of this phenomenon has been given by Lighthill (36). On the basis of several experimental results for the sound field around a typical jet aircraft engine on the ground, Lilley (37) suggests a more complicated quadrupole field. A thorough analysis of the directional characteristics of the noise from a circular jet of one-inch diameter has also been presented. Experimental studies of the noise field of a small jet (38) have indicated that the index in the power law for velocity increases with frequency but varies with the angle from the jet. The flow behavior of various types of jets and nozzles has been examined to suggest the possible existence

of toroidal vortices (39). The shock pattern has also been correlated with the photographed sound waves (40, 41).

Scale effects on noise field have been studied in references (42) (43). A series of subsonic jets ranging from 3/4 inch to 12 inches in diameter have been employed (42) and the results compared with those from a turbojet engine. The noise produced varies with direction and is dependent on the jet size, velocity, density and turbulence level. In a given direction the noise level is approximately equal at distances of an equal number of jet diameters for different size jets. Turbulence level is shown to be a vital factor in assessing noise level. The Mach number and Reynolds number effects on Lighthill's power coefficient, K, have been studied (43), using jets from 1/4 to 1.5 inches in diameter. The dimensionless coefficient K seems to be almost independent of these and is of the order of 10^{-4}.

E. J. Richards (44) has enumerated various mechanisms of noise production around jet engines. The noise fields around jet engines are compared with Lighthill's theory (44b). The noise produced seems to be independent of jet temperature, which is also implied in the theory. Lilley has pointed out (44c) that a large percentage of the total noise heard in aircraft cabins arises from boundary layers and wakes. The noise due to sudden pressure changes in the presence of shock waves around aircraft in supersonic flight is discussed in (44d).

Some of the features of turbulence-shock wave interaction and resonance phenomena in choked jets have been discussed in (45). The strength of the sound wave appears to depend largely on the strength of the vortex and less on the strength of the shock. Small velocity perturbations seem to have a strong influence on sound waves originating from the interaction. Temperature fluctuations appear to be sources of considerable noise in choked jets.

The noise field very close to the jet boundaries has been studied in references (46) and (47). The sound pressure magnitude on the surface of a panel placed in the near noise field of a jet is observed to be higher than it would be in free space at the same location. This increase is as high as 50-80% of the free-space value for the particular location of the panel reported in (46). Similar results are reported in (47). The increase is of practical interest and cannot be neglected in the design of a panel located close to the jet boundary.

A method of estimating the near noise field by distributing sources along the jet axis and assigning to each of them a power level and a directivity determined by the average velocity at its location has been suggested in (48). Far-field noise information is employed to fix the locations of the sources.

The far-field noise of jets has been investigated in (49) (50). Reference (49) is concerned with the effect of nozzle shape on jet-noise generation. A variety of nozzle shapes (circular, square, rectangular, elliptical, convergent and convergent-divergent) have been used in this investigation. In general, nozzle exit shape does not seem to have much effect on sound-power generation. At high pressure ratios, convergent-divergent nozzles appear to produce considerably less noise than do the convergent type. Noise measurements have been made in the far noise fields of air jets and turbojet engines under similar conditions; the results are compared in (50). The effect of shape of nozzle has also been treated in (51) by means of reverberation chamber techniques which determine the sound spectra and acoustic power radiated by subsonic air jets. The nature and magnitude of the differences in the noise field from subsonic cold air jets having circular and elliptic orifices has been investigated experimentally and is reported in (52).

The distribution and strength of noise sources in the jet has been studied theoretically by Ribner (53). Making use of existing data, an approximate axial distribution of sources is obtained by Dyer (54). It is shown that source distribution is densest about 3 or 4 diameters downstream of the nozzle; beyond 6 diameters downstream the source distribution density appears to decay rapidly, becoming almost insignificant at about 10 diameters.

In addition to measuring noise, many workers have attempted to suppress the noise generated aerodynamically. Since the noise increases as jet velocity to the power 8 in the subsonic range and to higher powers (up to 29) in supersonic range, one can infer that a great reduction in noise can be achieved by reducing the jet velocity. This is open to objection since thrust decreases with decrease of jet velocity. According to Lighthill's theory, noise arises from turbulence and velocity shear; consequently, minimizing any of these will result in noise reduction. In supersonic flow much of the noise arises from the interaction of turbulence and eddy motion with the standing shock waves and this is greatly amplified by back reaction. The use of any mechanism which decreases the turbulence or the strength of the shock waves, or which separates them will result in noise reduction. Devices introduced up to the present are intended to create one or more of these suppression mechanisms. A jet pipe with fingers inserted slightly into the jet stream around its periphery, corrugated jet pipe, use of wire gauze and swirl vanes well inside the nozzle, and use of water injection into the jet immediately after the exit are some of the methods tested. A method of using the secondary air flow to reduce noise has been reported recently (55, 58). The principle involved here is that the secondary flow combines with the primary one to form a jet stream of larger area and lower velocity and consequently low noise generation. The effect of secondary flow in reducing noise has been tested using concentric jets in a reverberant box (56, 57). In (56) tests at subsonic speeds have indicated that the secondary flow has little effect on noise reduction. In (57) the choked jet has been employed; it is found that under suitable conditions the secondary flow has a tendency to improve the stability of the shock formation and thus to eliminate screech noise.

Pulse jet noise arising from three different and distinct mechanisms—monopole, dipole and quadrupole sources—is described in (59). Preliminary analysis of this noise has indicated that its fundamental frequency is generated by a monopole radiation and that the higher harmonics contain monopole, dipole and quadrupole radiation.

Using the concept of space-time pressure correlation, acoustic radiation from isotropic turbulence is analyzed in (60). The spectrum at high frequencies is found to be independent of the details of the driving mechanism. At low frequencies it appears to be dependent on the large-scale eddies. Sound radiation from high Reynolds number turbulence is discussed and some implications of this radiation from jets, wakes and boundary layers are mentioned in (61). An approach to the correlation of available experimental data on jet noise radiation by plotting acoustic efficiency versus velocity ratios, densities and temperatures of the jet and ambient fluids is suggested in (62).

The magnitude and the rate of occurrence of peak pressures, in relation to the commonly measured r.m.s. pressure level in the near field of jet engines, is discussed in (63). The distribution of peak pressures does not seem to be of Rayleigh type and, in addition, it seems to be independent of physical position with respect to the jet stream and of frequency. The ratio of peak to r.m.s. pressure is shown to be larger than 4.

Results of experiments on boundary-layer noise are presented in (64). Evidence as to the mechanism of noise generation in the boundary layer is obtained and the noise variation is shown to be a function of velocity, density and surface roughness. Powell (65) discusses the noise generated in a boundary layer by quadrupole sources (layer noise), by dipole sources (surface noise) and finally by simple source radiation caused by surface vibrations induced by boundary-layer fluc-

tuations (panting noise). Rough comparisons are made between the magnitudes of these sources. It has been shown (66) that "panting noise" is zero and "surface noise" is relatively unimportant in comparison with "layer noise" for sound radiation from a turbulent boundary layer upon a rigid plane boundary.

REFERENCES

1 Fleming, N., The silencing of aircraft, *J. Roy. Aero. Soc.* pp. 639–676, Sept. 1946.

2 Richards, E. J., Research on aerodynamic noise from jets and associated problems, *J. Roy. Aero. Soc.* p. 318, May 1953; AMR **7** (1954), Rev. 952.

3 Miller, L. N., and Beranek, L. L., Noise levels inside the prototype Caravelle Twin-Jet Air Liner during flight, *J. Acoust. Soc. Amer.* **29,** 11, p. 1252, Nov. 1957.

4 Miles, J. W., An approach to the buffeting of aircraft structures by jets, Douglas Aircraft Co. Rept. SM-14795, 40 pp., June 1953; AMR **7**(1954), Rev. 1227.

5 Miles, J. W., On structural fatigue under random loading, *J. Aero. Sci.* Nov. 1954; also *J. Acoust. Soc. Amer.* **29,** 1, p. 176, Jan. 1957; AMR **8**(1955), Rev. 1678.

6 Jet Efflux—A symposium, *J. Roy. Aero. Soc.* Feb. 1957:

a Wolfe, M. O. W., The structural aspects of jet noise; AMR **11**(1958), Rev. 2368.

b Franklin, R. E., The excitation of structural vibrations by noise; AMR **11**(1958), Rev. 2369.

c Mead, D. J., The effect of structural damping upon the stresses due to jet efflux; AMR **11**(1958), Rev. 1996.

d Clarkson, B. L., Stresses produced in aircraft structures by jet efflux; AMR **11**(1958), Rev. 1995.

e Hetzel, K. W., Experimental study of the effects of jet noise on an aircraft structure; AMR **11**(1958), Rev. 2370.

f Simmons, J. C., Summary of the discussion; AMR **11**(1958), Rev. 2371.

7 Belcher, P. M., Use of high-intensity siren in fatigue testing of structures subjected to acoustic forcing, *J. Acoust. Soc. Amer.* **29,** 1, p. 176, Jan. 1957.

8 Hubbard, H. H., and Hess, R. W., Some comparisons of the response of simple panels to random and discrete noise, *J. Acoust. Soc. Amer.* **29,** 1, p. 176, Jan. 1957.

9 Hess, R. W., Lassiter, L. W., and Hubbard, H. H., A study of the response of panels to random acoustic excitation, *NACA RM* L55E13C, July 15, 1955.

10 Lassiter, L. W., Hess, R. W., and Hubbard, H. H., An experimental study of the response of simple panels to intense acoustic loading, *J. Aero. Sci.* p. 19–24, Jan. 1957; AMR **10**(1957), Rev. 2427.

11 Lassiter, L. W., and Hess, R. W., Calculated and measured stresses in simple panels subject to intense random acoustic loading including the near noise field of a turbojet engine, *NACA TN* 4076, Sept. 1957; AMR **11**(1958), Rev. 2367.

12 Hess, R. W., Fralich, R. W., and Hubbard, H. H., Studies of structural failure due to acoustic loading, *NACA TN* 4050, July 1957.

13 Kirchman, E. J., and Greenspon, J. E., Nonlinear response of aircraft panels in acoustic noise, *J. Acoust. Soc. Amer.* p. 854–857, July 1957; AMR **11**(1958), Rev. 1405.

14 Kennard, D. C., Jr., Sonic vibration as exemplified by the RB-66B airplane, *J. Acoust. Soc. Amer.* pp. 462–469, May 1958.

15 Smith, P. W., and Junger, M. C., Correlation of sonic damage with vibration tests, *J. Acoust. Soc. Amer.* **29,** 6, p. 776, June 1957.

16 Vogel, Sur les vibrations de certains systemes elastiques dans un champ sonore, *Publ. Scient. Tech. Min. Air, France*, no. 209, 1948.

17 Yeh, G. C. K., and Martinek, J., Forced vibration of a clamped rectangular plate in fluid media, *J. Appl. Mech.* **22,** 4, p. 568, Dec. 1955; AMR **9**(1956), Rev. 3183.

18 Yeh, G. C. K., and Martinek, J., Forced vibration of a viscoelastic rectangular plate in fluid media, Ninth Inter. Congr. Appl. Mech., Sept. 1956, Brussels; Pap. no. 116; AMR **12**(1959), Rev. 114.

19 Martinek, J., and Yeh, G. C. K., Forced vibration of a viscoelastic rectangular plate in fluid media, Reed Research, Inc., Washington, D. C., pp. 352–359, Mar. 27, 1956.

20 Martinek, J., and Yeh, G. C. K., Sound scattering and transmission by thin elastic rectangular plates, *Quart. J. Mech. Appl. Math.* **8,** pt. 2, June 1955; AMR **9**(1956), Rev. 660.

21 Kerwin, E. M., Jr., Vibration damping by a stiffened damping layer, *J. Acoust. Soc. Amer.* **30,** 7, p. 698, July 1958.

22 Kraichman, R. H., Noise transmission from boundary layer pressure fluctuations, *J. Acoust. Soc. Amer.* pp. 65–80, Jan. 1957; also WADC 56-263, (PB 121 894, ASTIA AD 110 523), Mar. 1956; AMR **12**(1959), Rev. 4190.

23 Strasberg, M., Response of plates and membranes to pressure fluctuations of a turbulent boundary layer, *J. Acoust. Soc. Amer.* **30,** 7, p. 680, July 1958.

24 Callaghan, E. E., Howes, W. L., and Coles, W. D., Near noise field of a jet-engine exhaust II–Cross correlation of sound pressures, *NACA TN* 3764, Sept. 1956; AMR **10**(1957), Rev. 919.

25 Harrison, M., Correlations and spectra of pressure fluctuations on the wall adjacent to a turbulent boundary layer, *J. Acoust. Soc. Amer.* **29,** 11, p. 1252, Nov. 1957.

26 Hubbard, H. H., A survey of the aircraft-noise problem with special reference to its physical aspects, *NACA TN* 2701, May 1952; AMR **6**(1953), Rev. 1080.

27 Lighthill, M. J., On sound generated aerodynamically, I: General theory, *Proc. Roy. Soc. Lond.* (*A*) **211,** 1952; AMR **6**(1953), Rev. 654.

28 Gerrard, J. H., Ph.D. Thesis, Manchester, 1953.

29 Lassiter, L. W., and Hubbard, H. H., Experimental studies of noise from subsonic jets in still air, *NACA TN* 2757, Aug. 1952; AMR **6**(1953), Rev. 1082.

30 Powell, A., *Aero. Res. Comm. London*, Rep. 15623.

31 Westley, R., and Lilley, G. M., An investigation of the noise field from a small jet and methods for its reduction, *Aero. Res. Comm. London*, Rep. 14719, 1952 (see Ref. 38).

32 Fitzpatrick, H. M., and Lee, R., Measurement of the noise radiated by supersonic air jets, David W. Taylor Model Basin Rep. 835, Nov. 1952; AMR **6**(1953), Rev. 2064.

33 Lighthill, M. J., On sound generated aerodynamically, II: Turbulence as a source of sound, *Proc. Roy. Soc. Lond.* (*A*) **222,** 1954; AMR **8**(1955), Rev. 851.

34 Proudman, I., The generation of noise by isotropic turbulence, *Proc. Roy. Soc. Lond.* (*A*) **214,** p. 119, 1952.

35 Powell, A., The mechanism and reduction of choked jet noise, I, II (Univ. of Southampton) (See refs. 102, 124, 128).

36 Lighthill, M. J., On the energy scattered from the interaction of turbulence with sound of shock waves, *Aero. Res. Comm. Lond. Rep.* 15432 (F.M. 1825), Dec. 1, 1952; AMR **7**(1954), Rev. 864.

37 Lilley, G. M., Aerodynamic noise work at the College of Aeronautics, presented at Congress of Applied Mech., Istanbul, 1952.

38 Westley, R., and Lilley, G. M., An investigation of the noise field from a small jet and methods for its reduction, Coll. Aero., Cranfield, Rep. 53 (ARC 14719–F.M. 1692–E.P.174, Jan. 1952) (see also Ref. 31).

39 Powell, A., Some experimental observations on the behavior of free air jets, Univ. of Southampton, May 1951.

40 Powell, A., Communicated by Prof. E. J. Richards (1951), First noise research interim report—A "Schlieren" study of small scale air jets and some noise measurements on two-inch diameter air jets, *Aero. Res. Comm. Lond. Rep.* 14726 (F.M.1694), Dec. 1, 1951.

41 Powell, A., Communicated by Prof. E. J. Richards (1952), On the noise emanating from a two-dimensional jet above the critical pressure, Dept. Aero. Engng., Univ. of Southampton, *Aero. Res. Comm. London, Rep.* 15472 (F.M. 1836) June 1952 (Also see ref. 104); AMR **7**(1954), Rev. 328.

42 Lassiter, L. W., and Hubbard, H. H., Experimental studies of noise from subsonic jets in still air, *NACA TN* 2757, Aug. 1952; AMR **6**(1953), Rev. 1082.

43 Lee, R., and Fitzpatrick, H. M., Measurements of turbulence noise radiated by small jets, *J. Acoust. Soc. Amer.* **25,** 1, p. 186, Jan. 1953.

44 Aeronautics Acoustics—In particular jet noise, *J. Roy. Aero. Soc.* **58,** no. 520, Apr. 1954:

a Richards, E. J., Jet engine noise, pp. 221–223; AMR **7**(1954), Rev. 3399.

b Greatrex, F. B., Engine noise, pp. 223–235; AMR **7**(1954), Rev. 3400.

c Lilley, G. M., Aerodynamic noise, pp. 235–239; AMR **7**(1954), Rev. 3401.

d Warren, C. H. E., Noise associated with supersonic flight; AMR **7**(1954), Rev. 3402.

45 Richards, E. J., On the noise from supersonic jets, *J. Roy. Aero. Soc.* **61,** no. 553, Jan. 1957; AMR **10**(1957), Rev. 1844.

46 Lassiter, L. W., and Hubbard, H. H., The near noise field of static jets and some model studies of devices for noise reduction, *NACA TN* 3187; AMR **10**(1957), Rev. 2333.

47 Howes, W. L., and Mull, H. R., Near noise field of a jet-engine exhaust, I: Sound pressures, *NACA TN* 3763; AMR **10**(1957), Rev. 2334.

48 Franken, P. A., and Dyer, I., Near field studies of jet noise, *J. Acoust. Soc. Amer.* **29,** 6, p. 779, June 1957.

49 Callaghan, E. E., and Coles, W. D., Investigation of far noise field of jets, I: Effect of nozzle shape, *NACA TN* 3590, Jan. 1956; AMR **9**(1956), Rev. 2034.

50 Coles, W. D., and Callaghan, E. E., Investigation of far noise field of jets, II: Comparisons of air jets and jet engines, *NACA TN* 3591, Jan. 1956; AMR **9**(1956), Rev. 2035.

51 Waterhouse, R. V., and Berendt, R. D., Reverberation chamber study of the sound power output of subsonic air jets, *J. Acoust. Soc. Amer.* pp. 114–121, Feb. 1958.

52 Powell, A., Experimental comparison between noise from unheated subsonic air jets having 4:1 elliptic and circular orifices, *J. Acoust. Soc. Amer.* pp. 642–643, July 1958.

53 Ribner, H. S., On the strength distribution of noise sources along a jet, *J. Acoust. Soc. Amer.* **30,** 7, p. 676, July 1958; AMR **12** (1959), Rev. 1583.

54 Dyer, I., Distribution of sound sources in a jet stream, *J. Acoust. Soc. Amer.* **30,** 7, p. 676, July 1958.

55 Westervelt, P. J., Dyer, I., and Franken, P. A., Changes of jet noise by mixing and an upper limit on jet noise production, *J. Acoust. Soc. Amer.* **29,** 6, p. 778, June 1957.

56 Lee, R., and Smith, E. B., Noise measurement of subsonic concentric jets, *J. Acoust. Soc. Amer.* **29,** 6, p. 779, June 1957.

57 Lee, R., and Smith, E. B., Effects of secondary flow on screech noise produced by choked jets, *J. Acoust. Soc. Amer.* **29,** no. 6, June 1957.

58 Dyer, I., Franken, P. A., and Westervelt, P. J., Jet noise reduction by induced flow, *J. Acoust. Soc. Amer.* p. 761, Aug. 1958; AMR **12**(1959), Rev. 2131.

59 Westervelt, P. J., and McQuillin, R. J., Theory of pulse jet noise generation, *J. Acoust. Soc. Amer.* **29,** 11, p. 1252, Nov. 1957.

60 Meecham, W. C., and Ford, G. W., Acoustic radiation from isotropic turbulence, *J. Acoust. Soc. Amer.* pp. 318–322, Apr. 1958; AMR **12**(1959), Rev. 2125.

61 Kraichman, R. H., Sound radiation from high Reynolds number turbulence, *J. Acoust. Soc. Amer.* **30,** 7, p. 675, July 1958.

62 Franken, P. A., and Dyer, I., Noise radiated by jet systems, *J. Acoust. Soc. Amer.* **30,** 7, p. 676, July 1958.

63 Kamps, E. C., Statistical evaluation of near field sound pressures generated by exhaust of a high performance jet engine, *J. Acoust. Soc. Amer.* **30,** 7, p. 692, July 1958; also *J. Acoust. Soc. Amer.* **31,** 1, 65–67, Jan. 1959; AMR **12**(1959), Rev. 5294.

64 Hubbard, H. H., Some experiments related to the noise from boundary layers, *J. Acoust. Soc. Amer.* pp. 331–334, Mar. 1957; AMR **11**(1958), Rev. 1816.

65 Powell, A., On noise generated by boundary layers, *J. Acoust. Soc. Amer.* **29,** 1, p. 176, Jan. 1957.

66 Philips, O. M., Aerodynamic sound radiated from a turbulent boundary layer, *J. Acoust. Soc. Amer.* **30,**7, p. 680, July 1958.

67 Powell, A., The problem of structural failure due to jet noise, *Aero. Res. Counc. Lond. Rep.* 17514, Mar. 1955.

68 Cooper, D. H. D., A suggested method of increasing the damping of aircraft structures, *Roy. Aero. Establ. Rep. SME 3382, 1946.*

69 Granick, N., and Thomas, C. E., Aircraft structural vibration induced by jet noise, WADC TN 56-514 (ASTIA AD 110 620); AMR 6 (1953), Rev. 1083.

70 Rodden, W., The flutter of two-dimensional panels on equally spaced supports in a supersonic flow, Ph.D. Thesis.

71 Browne, M. T., and Pattison, J. R., The damping effect of surrounding gases on a cylinder in longitudinal oscillation, *Brit. J. Appl. Phys.* **8,** 452–456, 1957.

72 Gershman, S. G., On the measurement of the coefficient of correlation (in Russian), *Akust. Zh.* **1,** 4, 326–338, 1955; AMR **10**(1957), Rev. 3387.

73 Cremer, L., The transmission impedence of a cylindrical shell (in German), *Acustica* **5,** 5, 245–256, 1955; AMR **10**(1957), Rev. 577.

74 Tatarskii, V. I., On the theory of the propagation of sound waves in a turbulent stream (in Russian), *Zh. Eksp. Teor. Fiz.* **25,** 1(7), 74–83, 1954; AMR **9**(1956), Rev. 943.

75 Smith, P. W., Jr., Sound transmission through thin cylindrical shells, *J. Acoust. Soc. Amer.* **29,** 6, 721–729, June 1957; AMR **10** (1957), Rev. 4208.

76 Mann-Nachbar, P., The interaction of an acoustic wave and an elastic spherical shell, *Quart. Appl. Math.* **15,** 1, 83–93, Apr. 1957; AMR **10**(1957), Rev. 3204.

77 Fay, R. D., and Fortier, O. V., Transmission of sound through steel plates immersed in water, *J. Acoust. Soc. Amer.* **23,** 3, 339–346, May 1951.

78 Schoch, A., Sound transmission through plates (in German), *Acustica* **2,** 1, 1–17, 1952; AMR **6**(1953), Rev. 1095.

79 Bleich, H. H., and Baron, M. L., Vibrations of shells in an acoustic medium, *J. Appl. Mech.* **21,** 2, 178–184, 1954.

80 Bleich, H. H., and Baron, M. L., Free and forced vibrations of an infinitely long cylindrical shell in an infinite acoustic medium, ASME Ann. Meet., New York, Dec. 1953, Pap. 53–A–37; AMR **7**(1954), Rev. 1301.

81 Young, J. E., Transmission of sound through thin elastic plates, *J. Acoust. Soc. Amer.* **26,** 4, 485–492, July 1954; AMR **8** (1955), Rev. 1525.

82 Lyon, R. H., Excitation of continuous systems by random noise fields, Ph.D. Thesis, Dept. of Phys., M. I. T., June 1955; Quart. Rep., Acoustics Lab., M. I. T. 30, Apr.–June 1955.

83 Kastner, S., The reflection and transmission of a plane sound wave incident at any angle on a layered viscoelastic medium (in German), *Ann. Phys.* **18,** 190–219, 1956.

84 Eichler, E. G., and Lambert, R. F., Acoustic (0,1) wave transmission through thin rectangular plates, *Acustica* **7,** 6, 379–386, 1957; AMR **12**(1959), Rev. 4968.

85 Kastner, S., The reflection and transmission of a plane sound wave incident at any angle on a layer-system visco-elastic medium (in German), *Ann. Phys.* **19,** nos. 3-5, p. 102–115, 1956.

86 Eringen, A. C., Response of beams and plates to random loads, ASME Ann. Meet., Nov. 1956, New York, Pap. 56–A–5; AMR **11**(1958), Rev. 60.

87 Lamb, G. L., Jr., The transmission of a spherical sound wave through a thin elastic plate, *Ann. Phys.* **1,** pp. 233–246, June 1957.

88 Miller, M. M., and Pollock, R., Noise considerations in aircraft structural design, *Noise Control* **1,** 50–52, Mar. 1955.

89 Itterbeek, A. V., and Myncke, H., Vibration of plates covered with a damping layer, *Acustica* **3,** 4, 207–212, 1953.

90 Westervelt, P. J., The theory of steady forces caused by sound waves, *J. Acoust. Soc. Amer.* **23,** 3, 312–315, May 1951.

91 Robertson, R. E., Random noise in an attenuating fluid medium, *J. Acoust. Soc. Amer.* **23,** 3, 353–358, May 1951.

92 Lienard, P., Kobrynski, M., and Antzenberger, P., Elements of aeronautical acoustics (in French), *ONERA Pub.* no. 40, 1950.

93 Merbt, H., and Brilling, H., The propeller as rotating sound source (in German), ZAMM **29,** 10, 301–311, Oct. 1949.

94 Kobrynski, M., On a method of calculating the noise spectrum of airplanes (in French), *Recb. Aero.* no. 11, 37–45, Sept.–Oct. 1949.

95 Odintsov, M. G., and Shaposhinkov, I. G., On the influence of large scale turbulence upon the propagation of sound in a turbulence medium (in Russian), *Zh. Tekh. Fiz.* **19,** 9, 1001–1009, Sept. 1949.

96 Middleton, D., On the theory of random noise, I, II, *J. Appl. Phys.* **22,** 9, 1143–1163, Sept. 1951; AMR **6**(1953), Rev. 3923.

97 Von Gierke, H. E., Physical characteristics of aircraft noise sources, *J. Acoust. Soc. Amer.* **25,** 3, 367–378, May 1953.

98 Mawardi, O. K., and Dyer, I., On noise of aerodynamic origin, *J. Acoust. Soc. Amer.* **25,** 3, 389–395, May 1953; AMR **6**(1953), Rev. 3921.

99 Kramer, M., The aerodynamic profile as acoustic noise generator, *J. Aero. Sci.* **20,** 4, p. 280, Apr. 1953; AMR **6**(1953), Rev. 3579.

100 Lassiter, L. W., Noise from intermittent jet engines and steady-flow jet engines with rough burning, *NACA TN* 2756, Aug. 1952; AMR **6**(1953), Rev. 1086.

101 Uberoi, M. S., Eddy turbulence and random sound in a compressible fluid, *Proc. Camb. Phil. Soc.* **49,** 4, 731–734, 1953.

102 Blochdassault, P., On the acoustics of supersonic missiles (in French), *C. R. Acad. Sci., Paris* **237,** 1123–1126, 1953.

103 Walters, A. G., The noise from aircraft travelling with velocities greater than that of sound, *J. Roy. Aero. Soc.* pp. 719–720, Nov. 1953; AMR **7**(1954), Rev. 3044.

104 Walters, A. G., The noise from aircraft, *J. Roy. Aero. Soc.* pp. 65–71, Jan. 1954; AMR **7**(1954), Rev. 2693.

105 Kraichman, R. H., The scattering of sound in a turbulent medium, *J. Acoust. Soc. Amer.* **24,** 6, 1096–1104, Nov. 1953; AMR 7 (1954), Rev. 2684.

106 Krasilnikov, V. A., and Tatarsky, V. I., Dispersion of sound in turbulent flow (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **90,** 159–162, 1953; (English Translation NSF–tr–121, Office Technical Services, Washington, D. C.).

107 Powell, A., On the mechanism of choked jet noise, *Proc. Phys. Soc. Lond. (B)* **66,** 1039–1056, Dec. 1953.

108 Powell, A., On edge tones and associated phenomena, *Acustica* **3,** 233–243, 1953; AMR **7**(1954), Rev. 2695.

109 Powell, A., On the noise emanating from a two-dimensional jet above the critical pressure, *Aero. Quart.* **4,** 103–122, Feb. 1953; AMR **7**(1954), Rev. 328.

110 Trilling, L., On thermally induced sound fields, *J. Acoust. Soc. Amer.* **27,** 3, 425–431, May 1955; AMR **10**(1957), Rev. 3840.

111 Mawardi, O. K., On the spectrum of noise from turbulence, *J. Acoust. Soc. Amer.* **27,** 3, 442–445, May 1955; AMR **9**(1956), Rev. 1166.

112 Thomas, N., On the production of sound by jets, *J. Acoust. Soc. Amer.* **27,** 3, 446–448, May 1955; AMR **9**(1956), Rev. 2397.

113 Powell, A., A note on the sound from weak disturbances of a normal shock wave, *Aero. Res. Counc. Lond. Curr. Pap.* 194, 1955; AMR **10**(1957), Rev. 528.

114 Tyler, J. M., and Perry, E. C., Jet noise, *SAE Trans.* **63,** 308–320, 1955; AMR **10**(1957), Rev. 580.

115 Fowell, L. R., and Korbacher, G. K., A review of aerodynamic noise, Univ. Toronto Inst. Aerophys. UTIA Rev. no. 8, July 1955; AMR **9**(1956), Rev. 1646.

116 Mirels, H., Acoustic analysis of ram-jet buzz, *NACA TN* 3754, Nov. 1955; AMR **9**(1956), Rev. 2033.

117 Sretenskii, L. N., Radiation of sound by a rotating dipole (in Russian), *Akust. Zh.* **2,** pp. 93–102, 1956.

118 Anderson, A. B. C., Vortex-ring structure-transition in a jet emitting discrete acoustic frequencies, *J. Acoust. Soc. Amer.* **28,** 5, p. 915, Sept. 1956; AMR **10**(1957), Rev. 918.

119 Richardson, E. G., Acoustics in relation to aerodynamics. *J. Aero. Sci.* **22,** 11, 775–780, Nov. 1955.

120 Yudin, F. Y., On the sound power of noise made by the elements of air outlets (in Russian), *Akust. Zh.* **1,** 4, 368–382, 1955.

121 Copeland, W. C., Aircraft noise, *Flight* **66,** p. 932, Dec. 1954.

122 Merle, M., On the frequency of sonorous waves emitted by an air jet at great velocity (in French), *C. R. Acad. Sci., Paris* **243,** 5, 490–493, July 1956.

123 Mawardi, O. K., Aero-thermoacoustics (The generation of sound by turbulence and by heat processes), Repts. Progress in Phys. **19,** pp. 156–186, 1956; AMR **11**(1958), Rev. 4280.

124 Curle, N., The influence of solid boundaries upon aerodynamic sound, *Aero. Res. Counc. Lond. Rep.* 17373, Feb. 1955: AMR **9**(1956), Rev. 1293.

125 Frunken, P., Review of information on jet noise, *Noise Control* **4,** pp. 8–16, May 1958.

126 Rollin, V. G., Effect of jet temperature on jet-noise generation, *NACA TN* 4217, Mar. 1958; AMR **11**(1958), Rev. 3806.

127 Beranek, L. L., Elwell, F. S., Roberts, J. P., and Taylor, C. F., Experiments in external noise reduction of light aeroplanes, *NACA TN* 2079, May 1950.

128 Barkhatov, A. N., and Shmelev, I. I., The attenuation of a sound beam on traversing a layer having velocity discontinuity (in Russian), *Akust. Zh.* **4,** 2, 125–127, 1958; AMR **12**(1959), Rev. 4173.

129 Powell, A., The noise of choked jets, *J. Acoust. Soc. Amer.* **25,** 3, 385–389, May 1953; AMR **6**(1953), Rev. 3924.

130 Regir, A. A., and Hubbard, H. H., Status of research on propeller noise and its reduction, *J. Acoust. Soc. Amer.* **25,** 3, 395–404, May 1953; AMR **6**(1953), Rev. 3922.

131 Hubbard, H. H., Propeller-noise charts for transport airplanes, *NACA TN* 2968, June 1953; AMR **7**(1954), Rev. 324.

132 Lee, R., Free field measurements of sound radiated by subsonic air jets, David Taylor Model Basin Rep. no. 868, 15 pp., Dec. 1953; AMR **7**(1954), Rev. 3043.

133 Powell, A., The reduction of choked jet noise, *Proc. Phys. Soc. Lond.* (*B*) **67,** 313–327, Apr. 1954; AMR **7**(1954), Rev. 3405.

134 Powell, A., A survey of experiments on jet noise, *Aircr. Engng.* **26,** pp. 2–9, Jan. 1954; AMR **7**(1954), Rev. 1652.

135 Powell, A., The influence of the exit velocity profile on the noise of a jet, *Aero. Quart.* pp. 341–360, Feb. 1954; AMR **7**(1954), Rev. 3760.

136 Hubbard, H. H., and Lassiter, L. W., Experimental studies of jet noise, *J. Acoust. Soc. Amer.* **25,** 3, 381–384, May 1953; AMR **7** (1954), Rev. 326.

137 Hubbard, H. H., and Lassiter, L. W., Some aspects of the helicopter noise problem, *NACA TN* 3239, Aug. 1954; AMR **8**(1955), Rev. 3560.

138 Lassiter, L. W., and Heitkotter, R. H., Some measurements of noise from three solid-fuel rocket engines, *NACA TN* 3316, Dec. 1954; AMR **9**(1956), Rev. 2666.

139 Lassiter, L. W., and Hubbard, H. H., Some results of experiments relating to the generation of noise in jets, *J. Acoust. Soc. Amer.* **27,** 3, 431–437, May 1955; AMR **9**(1956), Rev. 2762.

140 Kamrass, M., and Swartzel, K. D., Evaluation of noise field around jet-powered aircraft, *Noise Control* **1,** pp. 30–39, 1955.

141 Pietrasanta, A. C., Noise measurements around some jet aircraft, *J. Acoust. Soc. Amer.* **28,** no. 3, May 1956; AMR **9**(1956), Rev. 3791.

142 Merle, M., Sound waves emitted by an air jet (in French), *C. R. Acad. Sci., Paris* **240,** 21, 2055–2057, May 1955.

143 Kurbjun, M. C., Noise survey of a 10-ft four-blade turbine-driven propeller under static conditions, *NACA TN* 3422, July 1955; AMR **9**(1956), Rev. 589.

144 Miller, L. N., and Beranek, L. L., Comparison of the take-off noise characteristics of the Caravelle jet airliner and of conventional propeller-driven airlines, *J. Acoust. Soc. Amer.* **29,** 11, 1169–1179, Nov. 1957.

145 Kurbjun, M. C., Noise survey of a full-scale supersonic turbine-driven propeller under static conditions, *NACA TN* 4059, July 1957; AMR **11**(1958), Rev. 2835.

146 Franklin, R. E., Noise measurements on cold jets using convergent-divergent nozzles, *Aero. Quart.* pp. 346–359, Nov. 1957; AMR 11(1958), Rev. 4284.

147 Callaghan, E. E., and Coles, W. D., Far noise field of air jets and jet engines, *NACA Rep.* 1329; AMR **11**(1958), Rev. 4285.

148 Powell, A., On the effect of missile motion on rocket noise, *J. Acoust. Soc. Amer.* **30,** 11, p. 1048, Nov. 1958; AMR **12**(1959), Rev. 2671.

149 Hilliard, J. K., and Fiala, W. T., Methods of generating high-intensity sound with loud speakers for environmental testing of electronic components subjected to jet and missile engine noise, *J. Acoust. Soc. Amer.* **30,** 6, 536–538, June 1958.

150 Cook, R. K., et al, Measurement of correlation coefficients in reverberant sound fields, *J. Acoust. Soc. Amer.* **27,** 6, 1072-1077, Nov. 1955; AMR **9**(1956), Rev. 2026.

151 Merle, M., New researches on the ultrasonic frequencies produced by air jets (in French), *Ann. Telecomm.* **12,** 12, 424–426, Dec. 1957.

152 Chernov, I. A., Correlation of field fluctuations, *Sov. Phys.-Acoustics* **3,** 2, 203–206, 1957 (English translation of *Akust. Zh.* by Amer. Inst. Phys.); AMR **11**(1958), Rev. 5092.

153 Lassiter, L. W., Turbulence in small air jets at exit velocities up to 705 feet per second, *J. Appl. Mech.* **24,** 349–354, Sept. 1957; AMR **11**(1958), Rev. 1054.

154 Merle, M., Nouvelles recherches sur la structure des jets d'air a'grande vitesse et les frequences ultrasonores emises, *J. Phys. Radium,* **18,** 665–695, Nov. 1957; *Ann. Telecomm.* 101169, Feb. 1958.

155 Suchkov, B. A., Sound amplitude fluctuations in a turbulent medium (in Russian), *Akust. Zh.* **4,** 1, 85–91, 1958.

156 Young, J. E., Correlation functions for noise fields, *J. Acoust. Soc. Amer.* **26,** 5, 788–789, 1954; AMR **11**(1958), Rev. 337.

157 Veneklasen, P. S., Noise characteristics of pulse-jet engines, *J. Acoust. Soc. Amer.* **25,** 3, 378–380, May 1953; AMR **6**(1953), Rev. 3580.

158 Oberst, H., Becker, G. W., and Frankfeld, K., Uber die Dampfung der Biegeschwingungen Dunnen Bleche durch Fest Haftende Belage, II (The damping of the flexural vibrations of thin sheet metal with a strongly adhering coating, II), *Akust. Beiheft,* no. 1, pp. 433–444, 1954; AMR **8**(1955), Rev. 351.

159 West, F. L., A brief review of the problem of exhaust silencing, *Aero. Res. Counc. Lond. Rep. Mem.* 2803, May 1946, published 1954; AMR **8**(1955), Rev. 284.

160 Callaghan, E. E., and Coles, W. D., Investigation of jet engine noise reduction by screens located transversely across the jet, *NACA TN* 3452, May 1955; AMR **9**(1956), Rev. 945.

161 Callaghan, E. E., Sanders, N. D., and North, W. J., Recent NACA investigations of noise-reduction devices for full-scale engines, *Aero. Engng. Rev.* **14,** 6, 66–71, June 1955; AMR **9**(1956), Rev. 327.

162 North, W. J., Summary evaluation of toothed-nozzle attachments as a jet-noise-suppression device, *NACA TN* 3516, July 1956.

163 Hirschorn, M., Use of flat splitter construction in aviation test cell silencing, *J. Acoust. Soc. Amer.* **27,** 5, 969–973, Sept. 1955.

164 Tyler, J., A jet exhaust silencer, *Noise Control* **1,** 4, 37–41, July 1955; AMR **9**(1956), Rev. 487.

165 Phillips, O. M., On the aerodynamic surface sound from a plane turbulent boundary layer, *Proc. Roy. Soc. Lond.* (*A*) **234,** 327–335, Feb. 1956.

166 Sanders, N. D., and Callaghan, E. E., Jet engine noise reduction research at NACA, *Noise Control* **2,** 6, 43–48, Nov. 1956.

167 Bies, D. A., Caffrey, J. H., and Wilson, O. B., Jr., A study of internal acoustic absorbers as a technique for turbojet engine noise reduction, Soundrive Engine Co., Los Angeles, Calif. Final Rep. 94, Vols. 1 and 2, Aug. 1957 (Contract no. a(S)55–541–c, ASTIA AD 150 553 and AD 150 554.).

168 Ciepluch, C. C., et al, Acoustic, thrust, and drag characteristics of several full-scale noise suppressors for turbojet engines, *NACA TN* 4261; AMR **11**(1958), Rev. 4286.

169 Willmarth, W. W., Wall pressure fluctuations in a turbulent boundary layer, *J. Acoust. Soc. Amer.* **28,** 6, 1048–1053, Nov. 1956; also *NACA TN* 4129, Mar. 1958.

170 Corcos, G. M., and Liepman, H. W., On the transmission through a fuselage wall of boundary layer noise, Douglas Aircraft Co. Rep. SM–19570, Dec. 1955; AMR **10**(1957), Rev. 320.

171 Ribner, H. S., Boundary-layer-induced noise in the interior of an aircraft, Univ. Toronto, Inst. Aerophys. Rep. 37, Apr. 1956; AMR **10**(1957), Rev. 3839.

172 Solnick, R. L., and Bishop, R. H., Noise, vibration and measurement problems resulting from fluid-flow disturbances, *Trans. ASME* **79,** 1043–1056, July 1957; AMR **10**(1957), Rev. 4212.

173 Gerrard, J. H., An investigation of the noise produced by a subsonic air jet, *J. Aero. Sci.* **23,** p. 855, Sept. 1956; AMR **10**(1957), Rev. 917.

174 Von Gierke, H. E., et al, The noise field of a turbojet engine, *J. Acoust. Soc. Amer.* **24,** pp. 169–174, 1952.

175 Richards, E. J., Technical possibilities of reducing noise of jet aircraft, Shell Aviation News, no. 227, pp. 19–24, May 1957.

176 Withington, H. W., Silencing the jet aircraft, *Noise Control* **2,** 5, 46–53, Sept. 1956; AMR **9**(1956), Rev. 3112.

177 Vance, D. H., The use of vibration and shock control in reducing noise levels, *Noise Control* **2,** pp. 64–72, 1956; AMR **9**(1956), Rev. 3113.

Physics, General

Book—549. French, A. P., Principles of modern physics, New York, John Wiley & Sons, Inc., 1958, ix + 355 pp. $6.75.

Starting always from basic concepts the author treats, mostly in the order of chronological development, the classical theories of matter, light and electricity and passes logically to the classical quantum theory, relativity and wave mechanics. The book concludes with a chapter on the nucleus.

The special theory of relativity is developed almost along "popular" lines, and a short descriptive section is devoted to the general theory. Wave mechanics is presented with a minimum of mathematical treatment and the usual solutions of Schrödingers equation (particle in a box, potential barriers and the hydrogen atom) are given. Solution of the wave equation for the hydrogen atom is discussed in terms of the emergence of the quantum numbers and the mathematical nature of the R, θ and ϕ functions is not considered. A more detailed treatment of the ground state is, however, given in appendix. The electron structure in many-electron atoms is discussed on the basis of the Pauli principle and attention is also given to radiation, the Zeeman effect and other quantum mechanical applications. The chapter on the nucleus is mostly descriptive and contains a large amount of well-presented information.

Problems are provided at the end of each chapter, and the large number of illustrations together with the author's lucid style of presentation renders the book eminently suitable for use by students on the undergraduate level, as well as for preparatory reading to more advanced study.

J. J. Wannenburg, South Africa

Analytical Methods in Applied Mechanics

(See also Revs. 570, 572, 589, 603, 604, 610, 612, 613, 654, 659, 661, 665, 675, 742, 777, 806, 846, 854, 861, 862, 893, 898, 899, 972, 980, 981)

Book—550. Duschek, A., Lectures on higher mathematics, Vol. 2: Integration and differentiation of function of several variables; linear algebra; tensor fields; differential geometry [Vorlesungen über höhere Mathematik. Zweiter Band, Integration und differentiation der Funktionen von mehreren Veränderlichen. Lineare Algebra. Tensorfelder. Differentialgeometrie], 2nd ed., Wien, Springer-Verlag, 1958, viii + 401 pp. $11.45.

This admirable volume, completed just before author's death, is second of four-volume set and has the same qualities that made first volume notable [see AMR **12**(1959), Rev. 4261]. Author extends calculus of first volume by treating continuity, differentiation, integration, Taylor series, etc., of functions of several variables, including double series, mappings, plane curves, line integrals, Leibnitz' rule, etc. He then treats determinants, matrices, linear equations, vector and tensor analysis (for Cartesian case), differential geometry of surfaces and of curves in space. Appendix gives solutions of the not-too-plentiful problems. There is a good index.

Reviewer recommends book to readers of German.

B. Hoffman, USA

551. Amara, R. C., Application of matrix methods to the linear least squares synthesis of multi-variable systems, *J. Franklin Inst.* **268,** 1, 1–16, July 1959.

Problem consists in generalizing Wiener's filters to a multi-input system characterized by a $p \times q$ matrix G. The unknown is a linear physically realizable, multivariable network to be cascaded with the given linear network, either for mere filtering purpose or for control purpose. It is characterized by the $q \times p$ matrix A. Solution has to minimize the sum of mean quadratic errors relating to the p input and output variables, the errors being equal either to differences between inputs and corresponding outputs, or between input and desired output. Inputs are random stationary time series, and their cross correlation matrix Φ_{rr} plays an important role. A matrix Φ_{ss} is deduced from matrix G.

Variational equations lead to a matrix generalization of Wiener-Hopf integral equation. As particular cases, author deals with diagonal Φ_{ss} and Φ_{rr} matrixes. Standard methods are used to diagonalize Φ_{rr} matrix, i.e. to find a linear transform characterized by a matrix U such that $\hat{\Phi}_{rr} = \tilde{U}^T \Phi_{rr} U$ ($\tilde{U}^T$ is the transposed conjugate of U). Another particular case is where the matrix G is "minimum phase," i.e. when its determinant has no zeros in the right half S plane. An appendix treats the case of a 2×2 matrix.

Reviewer believes this work is original, inasmuch as it deals with a very general problem. It is a very fine piece of mathematics whose field of application could not be found so easily. In particular, the transformation U operated on the matrix Φ_{rr} in order to get a diagonal matrix Φ_{rr} is not shown to possess any immediate physical embodiment.

Misprints: p. 9 line 22 read twice $\hat{\Phi}_{rr}$ instead of Φ_{rr}

J. M. Loeb, France

552. Ostrowski, A. M., On the convergence of the Raleigh quotient iteration for the computation of the characteristic roots and vectors. Part II, *Arch. Rational Mech. Anal.* **2,** 5, 423–434, Feb. 1959.

Author uses an iteration formula given in an earlier paper of the same title to speed up the convergence of the iteration process to the characteristic roots and vectors of real n-square symmetric matrices. It is shown that the iteration formula is valid in the case of eigenproblems arising in the form $A\xi = \lambda B\xi$, for A, a real symmetric n-square matrix, and B, a positive definite symmetric n-square matrix.

J. Jones, Jr., USA

Book—553. Cesari, L., Asymptotic behavior and stability problems in ordinary differential equations (Ergebnisse der Mathematik und ihrer Grenzgebiete, no. 16), Berlin, Springer-Verlag, 1959, vii + 271 pp. DM 68. (Paperbound)

The literature on title subject has grown extensively during the past few decades, and purpose of present volume is to "present many of the viewpoints and questions in a readable short report for which completeness is not claimed." Many proofs are sketched and details often omitted, but copious bibliographic notes and comments are sprinkled throughout the text. The bibliography itself takes up 69 pages. We have here a valuable guide to the literature and a source book for future research effort.

There are four chapters. The first deals with the various concepts of stability and linear systems with constant coefficients. Chapter 2 treats linear systems with variable coefficients and periodic coefficients, and the second-order linear differential equation and generalizations. Chapter 3, perhaps the most valuable, studies nonlinear systems. Two sections are devoted respectively to the first and second methods of Lyapunov (for a detailed study of the second or direct method of Lyapunov, see the following review). A third section takes up analytical methods and a number of applied examples associated with the names of Rayleigh, van der Pol, Lienard and others are presented. The fourth section concerns analytic-topologic methods. General asymptotic developments is the subject of Chapter 4.

Y. L. Luke, USA

Book—554. Hahn, W., Theory and application of the direct method of Lyapunov [Theorie und Anwendung der direkten Methode von Ljapunov] (Ergebnisse der Mathematik und ihrer Grenzgebiete no. 22), Berlin, Springer-Verlag, 1959, vii + 142 pp. DM 28. (Paperbound)

Lyapunov's fundamental work on stability theory first appeared in Russian in 1893 and was translated into French in 1907. His work lay rather dormant until about the early 1930s when Russian mathematicians reopened the subject. They noted that Lyapunov's ideas (especially the so-called second or direct method) are particularly useful to solve many applied problems. Though Lyapunov originally used his technique to obtain stability criteria in theoretical mechanics, it is now used in practical problems of mechanical and electrical oscillations, reactor dynamics, and automata.

The theory of the direct method has been advanced in recent years, and purpose of this volume is to summarize the important results. Author has rendered a valuable service since nearly all the published material is originally in Russian and much of it has appeared in inaccesible places. This is an important work and should prove useful to both pure and applied workers.

The volume covers publications which deal with the direct method, be it to extend the theory or to use the method as a tool for solution of applied problems. Except for a few references, topological aspects are omitted. The first two chapters deal with the elementary aspects of the theory. The treatment presumes a knowledge of basic differential equation and matrix theory. Application to engineering problems is the subject of Chapter 3. The basic theory of Lyapunov is extended in Chapters 4-7. Chapter 8 shows that the direct method is not limited to differential equations but may be used to construct more general theories of stability.

Y. L. Luke, USA

555. Dahlquist, G., Stability and error bounds in the numerical integration of ordinary differential equations, Trans. Roy. Inst. Technol., Stockholm no. 130, 85 pp., 1959.

In previous work, author studied application of difference equations of the form

$$\Sigma_{j=0}^{k} (\alpha_j y_{n+j} - h^r \beta_j f_{n+j}) = 0 \qquad [1]$$

to the numerical solution of differential equations of the form

$$d^r y/dx^r = f(x,y) \qquad [2]$$

in the case $r = 1$. Here h is the spacing in x, $f_n = f(x_n, y_n)$ and α_j and β_j are constants. Present paper generalizes many of these results for r any integer. Also studied are equations like [1] with $h^r \beta_j f_{n+j}$ replaced by $h\beta_j f_{n+j} + h^2 \gamma_j f'_{n+j}$ for the solution of [2] when $r = 1$. The latter results are then applied to analyze solutions of a general second-order differential equation. In this connection author finds some novel, accurate and stable methods. To illuminate the presentation, there are two sections devoted to numerical examples. This is a clearly written thesis and contains much valuable material.

Y. L. Luke, USA

556. Quinlan, P. M., Curve fitting and integral curves for nonlinear differential equations—A generalized step-function approach, AFOSR TN 59-65 (Natl. Univ. Ireland TN 5; ASTIA AD 209 609), 37 pp., Sept. 1958.

Author uses as interpolation formula a series of step functions each of which vanishes to the left of some point and is a simple polynomial to the right of that point. Numerous recurrence formulas, and applications to differentiation, integration, and differential equations are given; however, it is not clear that the method is generally superior to simpler and more conventional interpolation formulas.

C. E. Pearson, USA

557. Fichera, G., An introduction to the theory of singular integral equations (in Italian), *R. C. Mat. Appl., Univ. Roma* (5) **17**, 1/2, 82-191, Jan.-June 1958.

The theory of singular integral equations in 2-dimensional space is ordinarily based on holomorphic functions [see: N. I. Muskhelishvili, AMR **7** (1954), Rev. 3087; S. G. Mikhlin, AMR **12** (1959), Rev. 1118] but can also be connected with elliptic equations more general than $\Delta u = 0$, as shown by I. N. Vekua ["Systeme von Differentialgleichungen erster Ordnung vom elliptischen Typus, mit einer Anwendung in der Theorie der Schalen," VEB Deutscher Verlag der Wissenschaften Berlin, 1956]. Author develops a complete theory along these lines with an eye to possible extensions to n-spaces, $n > 2$. No application is indicated.

R. Conti, Italy

558. Stoilow, S., Theory of functions of one complex variable Vol. II, Harmonic functions. Riemannian surfaces [Teoria Functiilor de o Variabila Complexa. Vol. II. Functii Armonice. Suprafete Riemanniene], Bucarest, Editura Academiei Republicii Populare Romine, 1958, 378 pp. Lei 25.70.

The first five chapters of this volume cover entirely the classical theory of harmonic functions (Dirichlet problem and integral, local properties, extremum principles, singularities, capacity, etc.). The sixth chapter deals with the notion of harmonic measure (introduced in 1934 by R. Nevanlinna in connection with conformal mapping of multiply connected regions) and its applications. The remaining chapters (7 to 10), of a more abstract (topological) character, are devoted to the theory of Riemannian surfaces, open and closed, and contain an up-to-date exposition of results in this field, especially by Roumanian mathematicians.

R. Conti, Italy

Book—559. Chew, V., Experimental designs in industry (Statistics Series), Symposium at North Carolina State College, Nov. 5-9, 1956; New York, John Wiley & Sons, Inc., 1958, xi + 268 pp. $6.

The first part of this book consists of four rather lengthy expository papers reviewing experimental design in industrial research: V. Chew, "Basic experimental designs"; R. L. Anderson, "Complete factorials, fractional factorials and confounding"; R. J. Hader and A. H. E. Grandage, "Simple and multiple regression analyses"; G. E. P. Box and J. S. Hunter, "Experimental designs for the exploration and exploitation of response surfaces". Generally these papers are written in detailed pedagogic style and assume only little acquaintance with the basic ideas of statistics, significance tests and analysis of variance. Although much of the material is available in standard textbooks, this group of papers makes useful reading for anyone concerned with experimental design. Methodology in analysis of data is treated in more detail than in most textbooks. Of particular interest to the reviewer were Chew's discussions of the underlying concepts and assumptions of analysis of variance and the effects of the failure of these assumptions, and Box and Hunter's paper on the exploring of functional relationships to determine operating conditions for a best response.

Part II contains five short papers describing industrial experiences with incomplete block designs, fractional factorials, response surface designs, and design in ordnance experimentation.

The book concludes with a bibliography of 227 references to recent literature on experimental design.

E. W. Bowen, Australia

Computing Methods and Computers

(See also Revs. 552, 555, 556, 568, 589, 654, 658, 777)

Book—560. Warfield, J. N., Introduction to electronic analog computers, New York, Prentice-Hall, Inc., 1959, ix + 175 pp. $6.

In this relatively small book, author discusses in considerable detail some of the mathematics used in systems analysis as well as the topological aspects of analog computers through the use of signal flow diagrams. However, the treatment of general analog techniques and of the physical details of computer elements is so brief as to violate the rule that an introductory book should contain the basic material which will permit the novice to become informed in the fundamentals of the subject.

The headings of the principal chapters are: Characteristics of computers; Differential equations; Signal flow graphs; Simulation; Function generation; Difference equations; and Introduction to systems engineering. The Appendices include sections on the Description and analysis of some analog computer elements, and Laboratory experiments. J. E. Goldberg, USA

561. Paschkis, V., Combined geometric and network analog computer for transient heat flow, *ASME Trans.* **81C** (*J. Heat Transfer*), 2, 144–150, May 1959.

"A method to analyze three-dimensional transient heat flow is described, which comprises a continuous resistance medium but discrete capacitances. After describing the principles of the technique, the several components and their criteria are discussed, and the accuracy is illustrated by comparing the results of several simple problems with analytically determined values."

From the author's description of an analog method combining lumped capacitance elements with a distributed resistance medium, it is clear that the method not only involves inherent basic drawbacks, but also requires careful and tedious technique (and considerable experience) on the part of the user, if results of even modest accuracy are to be obtained. A pertinent discussion by R. P. Benedict following the paper also permits the same conclusion. The method is interesting for pedagogical purposes, but reviewer believes that it will otherwise find limited application, since precise, numerical solutions can be obtained more rapidly and inexpensively by high-speed digital computer techniques, probably even in cases where boundary complexity requires use of a fine mesh size. L. Green, Jr., USA

Analogies

(See Revs. 560, 561, 742, 772, 811, 1003)

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 657, 665, 980, 1007, 1027)

562. Kuzovkov, N. T., On the motion of gyrostabilized platforms for large deviation angles (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 44–51, Jan. 1958.

Author develops differential equations for a two-axial gyrostabilized platform valid for large deviation angles. Euler's equations are applied to each element of the system. These are then combined to give a set of nonlinear differential equations for the platform, two gyros, a frame and two control servos.

The differential equations are linearized by the small-perturbation method for the case of the stationary reference frame and shown schematically in block diagram form. The analysis shows that for certain conditions and deviation angles the system becomes unstable.

Reviewer believes that although the method used is standard for the solution of such problems, the results obtained are unique. V. Chobotov, USA

563. Tolstoi, D. M., and Pan, Bin-yaoo, The force jump when the device is stopped (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **114,** 6, 1231–1234, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6291.

Results are given of experiments for the determination of the relation of the coefficient of friction to the velocity when the device is running at low speeds; also a description of the device used. It is shown that the "momentary jump" of the friction force when stopped is absent in all the cases investigated, while the velocity characteristics differ significantly from the linear and possess a steeply rising curve at very low speeds.

A. S. Petrov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

564. Gauzy, H., Change of natural frequencies of a perturbed system (in French), *Recb. Aêro.* no. 59, 39–45, July-Aug. 1957.

Author investigates several theoretical considerations for vibrating mechanical system of discrete points perturbed by additional masses. These have practical application in the experimental measurement of generalized masses by method developed in France by members of the O.N.E.R.A. Author finds first that necessary and sufficient condition for the natural modes of vibration not to change is that mass perturbations be proportional to original mass distribution of system. However, since this criterion is impractical, he also investigates effect of perturbing only one mass and finds that the influence is negligible provided that the mass perturbation is small. A simple approximate formula for finding the generalized mass in terms of the natural and perturbed frequencies is obtained. The implications of these findings are discussed. P. Seide, USA

565. Fedorchenko, A. M., Method of canonical determination of the mean in the theory of nonlinear vibrations (in Russian), *Ukr. Matem. Zh.* **9,** 2, 220–224, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10788.

A method is demonstrated for the canonical averaging of mechanical systems, the Hamiltonian aspect of which depends periodically on time and which has the form of $\varepsilon H(p, q, t)$. Distinct from the usual method of averaging, it is not the system which is subjected to obtaining the mean but its Hamiltonian form. The method consists in finding the evolved function $S(P_i, q_i, t)$ which gives the contact transformation of the canonical variables according to the formulas

$$p_i = \frac{\partial S}{\partial q_i}, \quad Q_i = \frac{\partial S}{\partial P_i}$$

$$\frac{\partial S}{\partial t} + H\left(q_i, \frac{\partial S}{\partial q_i}; t\right) = H'(P_i, Q_i)$$

in such a way that "time" should not enter into the converted Hamiltonian H'. The function S is sought in the form of $S = S_0 + \varepsilon S_1 + \varepsilon_2 S_2 + \ldots$. The first approximation gives

$$S_0 = \sum q_i P_i, \quad \frac{\partial S_1}{\partial t} + H(P, q, t) = H_1'(P, q)$$

$$H_1' = \frac{1}{2\pi} \int_0^{2\pi} H(P, Q, t)\, dt = H_0(P_i, Q_i)$$

$$S_1 = i \sum \frac{H_n(P_i q_i) e^{int}}{n} \quad (i = \sqrt{-1})$$

In its practical application this method showed itself to be simpler than the general method of averaging, though the results are the same in the end. The method is exemplified on a spherical pendulum with a vibrating point in the suspension.

S. N. Shimanov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Instrumentation and Automatic Control

(See also Revs. 553, 554, 562, 948, 980)

Book—566. Cheng, D. K., Analysis of linear systems, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, xiii + 431 pp. $8.50.

This is a text for advanced undergraduate or first-year graduate students. The content may be seen from some of the chapter headings: Classical solutions of linear differential equations; Lumped-element electrical systems; Analogous systems; Analysis by Fourier methods; The Laplace transform; Systems with feedback; Sampled-data systems; Systems with distributed parameters.

Numerous illustrative examples are worked out in the text and numerous problems are given at the end of each chapter, for which answers are supplied. The typography and figures are excellent.

E. Saibel, USA

567. Smith, P. E., Jr., Design regulating systems by error coefficients, *Control Engng.* **2,** 11, 69–74, Nov. 1955.

Unlike a slave system, which must closely follow its input signal, a regulating system must not follow its input, which is usually a disturbance or change in load. Most of the techniques used to analyze regulating systems were first developed for slave systems and use system response to step inputs. If sudden changes of load are common, this is reasonable. But if, as is often true, the system is subjected to a varying load that does not change abruptly, a technique based on a gentler input is more logical.

The method of error coefficients is based on the assumption of an input that varies smoothly. Its techniques are partly mathematical, partly graphical. They are described here in detail and illustrated by three examples each on two kinds of plants.

From author's summary

568. Kalman, R. E., and Bertram, J. E., A unified approach to the theory of sampling systems, *J. Franklin Inst.* **267,** 5, 405–436, May 1959.

Paper deals with linear systems made up of three kinds of subsystems, namely, (1) continuous systems (described by differential equations), (2) sampling systems (described by difference equations), and (3) sample-and-hold elements (which convert, roughly speaking, a sampled signal into a continuous one). Other treatments of such systems have usually assumed synchronous and periodic sampling. The present one addresses itself to the manipulative difficulties introduced when this assumption is dropped. It is observed that the state of the system at any one time is completely specified by a finite set of numbers (the "state variables") and that any future state, because of system linearity, is computable in principle from the present state by a linear transformation of those state variables. The transformation matrix is called the "state transition matrix." A procedure is outlined for cataloging the state variables and calculating the elements of the transition matrix, "leaving the drudgery of numerical computation to be performed by a digital computer." Several illustrative applications are given.

R. F. Drenick, USA

569. Proskuriakov, A. P., Construction of periodic solutions of an autonomous system with one degree of freedom in the case of arbitrary real roots of the equation for the basic amplitudes, *Appl. Math. Mech. (Prikl. Matb. Mekh.)* **22,** 4, 709–720, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

570. Vichnevetsky, R., Nonlinear optimization of servomechanisms (in French), *Acad. Roy. Belgique, Bull. Cl. Sci.* (5) **44,** 5, 493–502, May 1958.

A slight variant of the usual switching problem: stepwise changes in an adjustable parameter follow changes in sign of a discriminator; optimizing criterion is minimum response time for step input. Author considers second-order system with discriminator output 0, $+a$, $-b$ applied to velocity-feedback coefficient. Results are illustrated experimentally.

N. Ream, England

571. Assadourian, A., Ground simulator studies of a nonlinear linkage in a power control system, NASA Memo 2-15-59L, 18 pp., Apr. 1959.

The ease and precision with which pilots performed various tracking tasks are compared with those for a normal linear control-stick system. The pilots were able to track almost as well with the nonlinear linkage installed as with the normal linear system. However, the pilots considered that the nonlinearity was an undesirable feature in the control system because of the apparent lack of simulator response through the neutral range of the linkage where relatively large stick motions could be made with very little simulator motion. Higher and somewhat uneven stick forces also characterized the tracking tasks made with the nonlinear linkage when compared with the normal linear system.

From author's summary

572. Krasovskii, N. N., Some problems of stability of nonlinear systems (in Russian), Avtoref. Diss. Dokt. Fiz.-Metem. Nauk, In-ta Mekh., Akad. Nauk SSSR, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 154.

573. Challe, J. H., Application of the method of finite differences for the solution of automatic temperature control of systems with large thermal inertia (in French), *Automatisme, Paris,* **4,** 4, 138–143, Apr. 1959.

Paper deals with the temperature control of a large thermal inertia system. Author considers the system to be controlled as a continuous medium formed by n identical four-poles with the same time constant $T = RC$, where R is the reciprocal of the thermal conductivity per unit volume and C the thermal capacity. With this model author applies Laplace's transformation technique starting with the operator $1/(1 + pT)$ for each link and obtaining the corresponding expression for the whole chain. The result of this analysis is: a system of the nth order can be replaced by a system of the first order on condition that a certain (fictitious) time lag τ be added. Having established this procedure, author applies it to three cases. (1) Idealized case in which the output signal is assumed to be proportional to the input signal without time lag. (2) A less idealized case is assumed; the amplitude of the output signal is fixed but its duration varies. One finds that in the first approximation the result is the same as in (1). Finally, in case (3), one introduces a certain time lag τ in the calculation. It is shown that the regulation is still expressed in terms of the same difference equation but the discrete variables are now shifted by the time lag.

N. Minorsky, Italy

574. Ransford, C., and Rottner, J., The optimization of hydraulic governor performance taking account of the grid inherent stability factor and elastic water hammer effects—case of Pelton turbines (French and English versions), *Houille Blanche* **14,** 1, 23–46, Jan.–Feb. 1959.

The first part of the article deals with the governing of a Pelton turbine taking account of the elastic water hammer and the grid inherent stability factor. Within the stable zone, values of the integral typifying the accuracy of governing are determined (in a similar way to a previous treatment dealing with Francis turbines). The results are given on six diagrams.

In the second part of the article, a concrete case is analyzed. In particular, the variation of speed of the machine after a load change is analyzed, using the optimum governing parameters determined by the preceding treatment.

From authors' summary

575. Sawaragi, Y., and Yonezawa, Y., On a cycling phenomenon in an actual control system caused by a backlash element in a pneumatic controller, *Bull. JSME* **2,** 5, 39–43, Feb. 1959.

Authors analyzed a cycling phenomenon in an actual control system and, as a result of some experiments, came to the conclusion that this phenomenon was caused by a backlash element in the pneumatic controller.

Carrying out the analysis of the control system including this nonlinear characteristic by the use of the gain-phase plane, it was found that the cycling frequency and amplitude were in good agreement with the experimental results. The larger the sensitivity of the proportional action controller is, the larger the frequency and the amplitude of the cycling.

From authors' summary

576. Mastovsky, O., A synchronizing governor (in Czechoslovakian), Survey of Lectures, Scientific Conference of the Technical University in Prague, 1958; 65–71.

Precise governing is often derived from a guiding device. With the governor designed by author for the control of steam turbines (Czsl. pat. No 51568), a pilot motor—small electrical motor or a tiny Pelton wheel driven by oil—is used. By means of a hydraulic coupling an inertia element is driven which is connected with the turbine shaft by means of centralizing springs. The oil-distributing rotary valve is connected with the inertia element and its sleeve with the turbine shaft. Thus the speed of the turbine is guided by the pilot motor, revolutions of which can be kept either constant or arbitrarily changed.

Dynamic solution of the regulating process and stability condition are established, and as example a solution for a 100-MW turboset is given. M. Nechleba, Czechoslovakia

577. Bruevich, N. G., The inlets and outlets of complex devices of continuous action (in Russian), Session of Akad. Nauk SSSR for the study of scientific problems in the automization industry, Moscow, Akad. Nauk SSSR, **6,** 1957, 93–131; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 4998.

578. Koronkevich, A. I., The dynamical systems subjected to accidental forces (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, Lvovsk In-ta, Lvov, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 74.

579. Kel'son, A. S., Self-aiming as a problem of engineering cybernetics, *Doklady Akad. Nauk SSSR (N.S.)* **116,** 6, 933–936, 1957. (Translation by Morris D. Friedman, P. O. Box 35, W. Newton, Mass., K-169, 6 pp).

580. Weir, E. V., Logic circuits for machine control, ASME Design Engng. Conf., Philadelphia, Pa., May 1959. Pap. 59-MD-10, 12 pp.

Elasticity

(See also Revs. 609, 619, 623, 624, 633, 638, 643, 648, 654, 666, 686, 688, 723, 750, 767)

581. Bhagavantam, S., Third order elasticity, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 25–30.

Author points out the opportunity of retaining the third-order terms in the elastic potential expansion to explain phenomena, such as rock bursts in mines, due to strong internal tensions. The number of the third-order elastic constants is given for the various crystal classes, while, for isotropic systems and uniform pressures, the experimental results are compared with those calculated by Murnaghan's formula. T. Manacorda, Italy

582. Doshchinskii, G. A., The theory of the limiting elastic state (in Russian), *Izv. Tomskovo Politekhn. In-ta* **85,** 343–354, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7983.

It is proposed to use the limiting value for the mean square of the main relative extensions as the limiting elastic state condition for isotropic materials. On the basis of Hooke's law this condition is represented by the two first invariants of the tensor for the stresses; it is revealed that the proposed condition is a generalization of the known conditions for limiting elastic states, and is satisfactorily confirmed by known experimental data.

L. A. Tolokonnikov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

583. Save, M., Remarks about plane strain and plane stress problems (in French), *Bull. Centre Etudes, Recherches, Essais Scient. Genie Civ., Liege* **9,** 63–84, 1957.

These problems are similar. Reduction of plane strain problems to plane stress is possible; whenever material yields according to to Guest's or Coulomb's law condition is $\sigma_1 \geq \sigma_2 \geq \sigma_3$.

In cases where this condition is not fulfilled there appears a transition phase between elastic state and plastic flow of rigid-plastic theory, with "restrained yielding." During transition the orientation of planes along which yielding takes place varies, and increased load is required. This is shown by author for materials yielding according to Tresca-Guest's and Coulomb's criteria. For Prandtl-Reuss materials yielding according to Huber-Hencky-von Mises' condition there cannot exist a plastic flow under constant load, for, in plane strain, any plastic deformation of such material is accompanied by a variation of σ_z from $\nu_{elast}(\sigma_1 + \sigma_2)$ to $1/2(\sigma_1 + \sigma_2)$. This does not agree with results of Drucker-Greenberg-Prager in *J. Appl. Mech.* **18,** 4, 371–78, Dec. 1951, and *Quart. Appl. Math.* **IX,** 4, 381–89, Jan. 1952 [AMR **5** (1952), Revs. 432, 1695].

Reviewer finds that lack of experimental evidence reduces greatly the value of paper. G. H. Beguin, Switzerland

584. Goodier, J. N., and Wilhoit, J. C., Jr., Elastic stress discontinuities in ring plates, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 152–170.

Displacement discontinuities in cut ring plates (in a state of plane stress and in flexure) are exhibited such that there are concomitant discontinuities in the components of stress and of surface traction across the cut. Six distinct discontinuities of this kind are discussed and the Kolosov complex representation determined for each. One of the examples given deals with a cut ring plate fixed along one face of the cut and subjected to a uniform normal load applied to one face of the plate.

H. Deresiewicz, USA

585. Roy, S. K., On the biharmonic analysis of stresses round openings in structures in relation to unlimited stress fields, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 57–74.

Author offers a method for the analysis of stress concentrations around openings of circular and square form in a two-dimensional stress field. Airy's stress function being known for the undisturbed stress field, the effect of circular opening is taken care of by an additive stress function which satisfies boundary conditions at both the internal and external boundaries. A modification of this additive stress function yields solution for a square opening.

Results are given for the cases of isotropic compression and pure shear, in terms of the additive stress function (χ) or of $\nabla^2\chi$. By superposition, solution for unidirectional compression is found.

Method can be adapted to stress concentration problems on openings of arbitrary shape. A. Foerster, USA

586. Waters, E. O., Theoretical stresses near a circular opening in a flat plate, reinforced with a cylindrical outlet, *ASME Trans.* 81A, (*J. Engng. Power*), 2, 189–200, Apr. 1959.

Formulas are derived for stresses in the neighborhood of a circular hole in a flat plate, reinforced with a cylindrical outlet. The plate is loaded in tension. Consideration is given to the possibility of "balanced reinforcement" by adding material on both sides of the plate. Tables and graphs are included for the use of designers who wish to find the stress-concentration factors for different combinations of plate thickness, outlet-wall thickness, and outlet diameter.

From author's summary by C. N. DeSilva, USA

587. Forray, M., Thermal stresses in rings, *J. Aero/Space Sci.* **26,** 5, 310–311 (Readers' Forum), May 1959.

Previous theory for plate subject to two-dimensional temperature distribution [AMR **12** (1959), Rev. 3236] is applied to ring of inner radius b and outer radius a. Stress function and stresses are given for temperature distribution

$$T = T_0 (r/a)^2 (1 - \cos\theta) + T_1$$

R. B. McCalley, Jr., USA

588. Glenny, E., Northwood, J. E., Shaw, S. W. K., and Taylor, T. A., A technique for thermal-shock and thermal-fatigue testing based on the use of fluidized solids, *J. Inst. Metals* **87,** 294–302, 1958/59.

A description is given of the development of a laboratory test for studying the behavior of materials under conditions of transient thermal stress, such as may be encountered by the turbine blading of a gas-turbine engine. The requirements of such a test are considered, and a number of possible methods of heating and cooling are reviewed. It is concluded that the most suitable laboratory testing technique is by immersion of the test specimen in a bed of powdered refractory substance supported on a permeable plate and fluidized by a stream of air. Fluidized beds are suitable for rapid heating as well as for rapid cooling experiments. The equipment for carrying out such tests, either separately or in combination, is fully described. The apparatus is simple to use, and is trouble-free in operation. The test conditions are uniform and reproducible, and can be accurately controlled.

From authors' summary

589. Kovalenko, A. D., Some problems of thermoelasticity in connection with thermal stresses in turbine rotors (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 68–76, Oct. 1958.

The equation for the nonsymmetric thermal deformation of a thin circular disk of symmetric profile is solved for a plane stress function or a deflection of the disk subjected to a sinusoidally symmetric temperature field which approximates the heat input from turbine blades to the rotor. The solution of the plane stress problem for a variable thickness is expressed, in general, by means of a hypergeometric series. The problem of the compound symmetric bending of a disk having a variable thickness and an elastic modulus varying through the thickness (with a three-dimensional axisymmetric temperature field) is solved by reducing it to a problem of a symmetric deformation of a circular plate of variable thickness with a small initial curvature. The four first-order differential equations of compound bending of a disk of arbitrary profile are integrated numerically by means of electromodeling on the differential analyzer of the Kiev State University, and the results are compared with analytical solutions for linearized profiles. Experiments were performed by studying static thermal deformations in disks and other turbine elements due to a high-frequency heating. Good agreement with theoretical results has been achieved.

The three-dimensional axisymmetric thermoelastic problem with an elastic modulus that varies exponentially through space is also solved. The solution is written in terms of a power series whose coefficients can be determined from recurrence relations.

M. I. Yarymovych, USA

590. Rozenblyum, V. I., On the analysis of thermal stresses in a turbine rotor at starting (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 80–83, Oct. 1957.

The transient axisymmetric problem of a long thick-walled cylinder with the temperature of the surrounding medium varying linearly along the axis is solved in closed form. The temperature distribution to be used in the solution is obtained from analytical or numerical solutions of the heat equation with the appropriate boundary conductance, or from experimentation. In the latter two cases a numerical integration of the equations of elasticity is called for. The radial displacements are expressed as $u(r,z) = (z/l)\, u^\circ(r)$, where $u^\circ(r)$ is the displacement due to a uniform temperature in the surrounding medium. The axial displacement is expressed in terms of a sum of a radial and an axial component. The end faces of the cylinder have to be loaded by self-equilibrating normal and shear stresses to maintain equilibrium. Thus the solution is not applicable to an arbitrary loading of the end faces.

M. I. Yarymovych, USA

591. Piechocki, W., The state of stress in a circular disk due to the action of a source of heat (in Polish), *Rozprawy Inz.* **6,** 4, 649–656, 1958.

The problem is reduced to that of determining the state of stress in a thin circular disk due to a point source of heat with constant capacity acting at any point inside the disk. The edge of the disk is free from stress. Using the potential of thermoelastic strain for the desired state of stress, a closed form is obtained.

M. Sokolowski, Poland

592. Rocha, M., and Serafim, J. L., Determination of thermal stresses in arch dams by means of models, Minis. Obras Publicas, Lab. Engen. Civ., Lisboa, Publ., Tech. Pap. 133, 28 pp., 1958.

Thermal stresses in concrete dams are very important, as the observation of these structures has shown. Cracks are noticed very often which are due to thermal stress. However, computation methods are not reliable for the prediction of such stresses.

Although the thermal conditions in the boundary of a dam are very complex, they can be separated into an annual, a 15-day and a daily cycle of temperature, the effects of solar radiation and exposure for the faces in contact with the air, and an annual cycle for the reservoir water at least down to a certain depth.

The success already achieved in the use of models for the determination of stresses due to hydrostatic pressure and other loads, and the fact that reliable measurements of thermal stresses are being obtained notably by aeronautical and mechanical engineers, not only by using common strain gages but especially by using special temperature compensated gages, led the Laboratorio Nacional de Engenharia Civil to undertake a wide research program for the determination of thermal stresses in concrete dams, especially in arch dams, by means of models. The similarity conditions which the models must fulfil, and the similarity ratios for stresses, strains, displacements and time in the models and in the prototypes taking the scales of dimensions, temperatures, moduli of elasticity and coefficients of thermal expansion allow a discussion of the advantages and disadvantages of the various materials for building the models.

Two systems for imposing temperature cycles were considered: one using oil baths heated and cooled by water circulating in coils immersed in them and the other by radiant heating and air cooling of the models.

Results already obtained in different preliminary tests using the common electrical strain gages have shown that such gages are reliable and also that the materials with best characteristics for the purpose are mortar, "perspex" and bronze. Models of large con-

crete arch dams using those materials are under construction and the temperature stress tests will begin soon.

From authors' summary

593. Gurland, J., Temperature stresses in the two-phase alloy, WC-Co, *Trans. Amer. Soc. Metals* **50,** 1063–1070, 1958.

594. Votinov, M. P., and Kuvshinskii, E. V., Thermoelastic phenomena in rubbers made from SKS-30A and SKB when being adiabatically deformed to rupture point (in Russian), *Zh. Tekh. Fiz.* **27,** 10, 2303–2306, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6213.

595. Votinov, M. P., Sul'zhenko, L. L., and Kuvshinskii, E. V., Thermoelastic phenomena in rubbers made from natural latex rubber during cyclic deformations (in Russian), *Zh. Tekh. Fiz.* **27,** 10, 2307–2313, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6214.

596. Kaliski, S., Cauchy's problem for a transversally isotropic elastic body (in English), *Arch. Mech. Stos.* **10,** 6, 825–838, 1958.

Introducing three displacement functions the equations of motion for a transversally isotropic body with five independent elastic constants are reduced to a simplified system of three differential equations. These are two equations of the fourth order and one equation of the second order, each of them containing only one displacement function. The equation of the second order is integrated, after a simple change of variables, by the classical Kirchhoff's formula.

To the remaining two equations the Fourier method is applied. In view of the necessity of using the basic solution the final equations for arbitrary mass forces and initial conditions have the form of double or quadruple integrals.

The solution imposes on the elastic constants of a transversally isotropic body certain conditions having the character of inequalities.

M. Sokolowski, Poland

597. Kulin, V. I., Certain equations for calculating for anisotropic plates with stiffener ribs (in Russian), *Sb. Nauchn. Trudí Belorussk. Politekhn. In-ta* no. 56, 265–273, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7910.

The problem is examined of the stability of a compressed rectangular orthotropic thin slab, of which two opposite sides are supported and the other two reinforced by identical stiffener ribs. It is assumed that the normal load p is evenly distributed along the supported sides, while forces associated in a prescribed manner with the load p, namely, $P = pl$, where l is the width of the rib, act on the ends of the ribs. The energetics method is used for solution. Author sets down an expression for the bending in the form

$$w = f(x) \sin \frac{m\pi y}{b}$$

and finally obtains a quite complex transcendental equation for determining the critical load, confining himself to writing it down. He gives no results of calculations. The equation given at the end of the article for the main shear modulus, with no indication of its source, arouses doubts.

S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

598. Kaliski, S., and Kurlandski, J., The basic solution and Cauchy's problem for a paratropic body (in English), *Arch. Mech. Stos.* **11,** 1, 61–70, 1959.

The solution of this problem is obtained by the method previously applied by S. Kaliski to orthotropic bodies [See: *Arch. Mech. Stos.* **10,** 6, 825–838, 1958]. Superposing on the 21 elastic constants of an anisotropic body six conditions characteristic for paratropic bodies, the number of independent coefficients of anisotropy is reduced to 15. By a judicious choice of oblique coordinates, the generalized Hooke's law is obtained in a form analogous to the case of the orthotropic body with nine independent constants. The basic solution is obtained by assuming that the dimensions of the parallelepiped under consideration are sufficiently great to exclude the interference of the reflected wave.

The basic solution has the form of infinite quadruple series of the problem.

M. Sokolowski, Poland

599. Shirely, L. K., and Stanisic, M. M., On the torsion of cylindrical beam having a trapezoidal cross section, *J. Aero/Space Sci.* **26,** 7, 462–464 (Readers' Forum), July 1959.

For solution of the problem, Prandtl's stress function is approached by a series of functions, each member of which satisfies the boundary conditions. The arbitrary parameters of these functions are determined by Galerkin's method. After having represented the general solution of the problem, its application is demonstrated in the case of a cylindrical beam with trapezoidal cross section. For sake of simplicity only the first member of the function series is taken into account. The solution given for the trapezoidal cross section is then applied to the particular case of the triangular cross section.

Reviewer believes that more exact results could have been obtained in the latter case directly without making use of the formulas of the trapezoidal cross section.

P. Csonka, Hungary

600. Poritsky, H., and Danforth, C. E., On the torsion problem, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 431–441.

Several graphical, approximate numerical, and exact analytical methods of solving the torsion problems are examined. These are illustrated on cross sections of relatively small thickness such as characterize blades of compressors and turbines, and on an angle-iron cross section of small thickness. The methods covered include small-square "flux plotting," approximations by means of harmonic polynomials, conformal mapping on a unit circle, an approximation to the stress function which is parabolic in the distance n from the "mean line," and others.

From authors' summary

601. Shiriaev, E. A., Torsion of a circular bar with two cuts, *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22,** 4, 768–773, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

The stress state due to torsion in a homogeneous isotropic circular bar having two cuts (cracks) along a diameter is studied by the conformal mapping method developed by N. I. Muskhelishvili in his book "Some basic problems of the theory of elasticity" [AMR 7 (1954), Rev. 2099]. Paper gives the expressions of the mapping function, the complex torsion function, the stresses on the circula part of the contour and at the edges of the cut, and the value of th torsional rigidity.

C. Massonnet, Belgium

602. Mintsberg, P. L., The problem of torsion of a half space (in Russian), *Prikl. Mat. Mekh.* **21,** 1, 116–118, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7839.

The problem of determination of the stresses and displacements in an elastic half-space, which is twisted by the rotation of a rigid cylindrical die fixed to the edge of the half-space, is examined. A solution was given to this problem in the book by L. A. Galin ["Contact problems in elasticity theory," Moscow, Gostekhizdat, 1953]. The distributions of stresses and deformations within an elastic half-space are investigated.

V. I. Mossakovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

603. Voronin, T. A., Contact stresses due to a tight fit of a rigid sleeve on a cylinder of an infinite length (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 153-155, 1957.

Article deals with the determination of pressure distribution on the surface of an elastic cylindrical shaft of an infinite length on which a hollow cylinder of finite length is assembled with a negative allowance. Author used for the solution a stress function suggested by G. S. Shapiro ["The compression of an infinite hollow circular cylinder due to the pressure applied on the area of a cylindrical surface," *Prikl. Mat. Mekh.* **7**, no. 5, 1943]. In his analysis, author considered the hollow cylinder to be an absolutely rigid body and disregarded tangential stresses arising in the surface layer of the shaft.

The final expression is presented in the form of an infinite series. Numerical solution indicates the number of terms of the series required to obtain a desired degree of mathematical accuracy.

Author mentions a possible approach for determining the contact stresses on the shaft by taking into account also the elasticity of the hollow cylinder but does not present an analysis of this case.

Reviewer believes that neglecting the effect of the elasticity of the hollow cylinder and the presence of tangential stresses will cause the results derived by the author to deviate significantly from the actual pressure distribution on the shaft surface. Assuming the hollow cylinder to be absolutely rigid will particularly influence the correctness of the solution.

E. I. Radzimovsky, USA

604. Young, D. H., and Brahtz, J. F., Torque-loaded continuous beams of profile section, *Proc. Amer. Soc. Civ. Engrs.* **85,** EM 2 (*J. Engng. Mech. Div.*), 37-46, Apr. 1959.

Profile section beams subjected to eccentric, transverse loads contain torsional shear as well as flexure stresses. The flexure stress can be handled easily by the well-established flexure theory. In this paper, author develops a general method for finding the shearing stresses and twist angles produced by the torque for the case where the beam is continuous over several spans.

A recurrence-type formula is derived which may be written once for each pair of consecutive spans. Thus the method is quite similar to the three-moment equation technique for bending moments. A two-span beam is solved using the method and experimentally checked. Agreement is found within 1.05%.

J. P. Vidosic, USA

Viscoelasticity

(See also Revs. 678, 691, 721, 740, 760, 1028)

605. Yamamoto, M., Phenomenological theory of viscoelasticity of three-dimensional bodies, *J. Phys. Soc. Japan* **14,** 3, 313-330, Mar. 1959.

Author derives constitutive laws of the Maxwell and Voigt types for finite deformations of viscoelastic solids. While these laws have the correct invariance properties, their theoretical value is hard to assess, because the generality of part of the discussion is invalidated by the highly special nature of some assumptions. Steady simple extension and steady simple shear are treated as examples.

W. Prager, USA

606. Finnie, I., A creep instability of thin-walled tubes under internal pressure, *J. Aero/Space Sci.* **26,** 4, 248-249 (Readers' Forum), Apr. 1959.

When a thin-walled tube of circular cross section, under constant internal pressure, deforms due to creep there is a continuous increase of radius and decrease of wall thickness. The stresses in the tube thus grow with time, which leads to an increasing rate of deformation. The purpose of the present note is to point out that this effect leads to a maximum tube life which can be predicted from tensile creep data.

From author's summary by D. Radenkovic, Yugoslavia

607. Nikitina, L. P., Relation between deformation and time in the second stage of creep (in Russian), Ispytania i svoistva zharoprochn. materialov, Moscow, Mashgiz, 1957, 175-188; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1379.

An analytical relation, based on generalization of experimental data, is established between the minimum speed of deformation ν_{min} and the duration of the second stage of creep θ_2. The following power relationship is proposed

$$\theta_2 = \left(\frac{\nu_o}{\nu_{min}}\right)^{\varphi}$$

The power exponent φ characterizes the stability of plastic properties of a material at this stage of process.

The established relation enables one to determine a margin of plasticity of a material, the value of a permissible life at the minimum speed of deformation or the permissible speed for a given life time. It appeared that it is possible to find a relation between θ_2, stress or temperature. The relation between ν_{min} and θ_2 enables one to estimate, on the basis of experimental data, the duration of the first period of creep at a given value of stress.

I. N. Danilova

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Plasticity

(See also Revs. 581, 655, 740, 754)

608. Chen, M. M., Inelastic diffusion in panels, AFOSR TN 59-33 (Mass. Inst. Techn., Aeroelastic Struct. Res. Lab. TR 76-1; ASTIA AD 209 205), 9 pp., Nov. 1958.

The problem of inelastic diffusion in stiffened panels has been studied. The governing ordinary differential equation has been solved numerically for the case where the Ramberg-Osgood exponent n is equal to 20. For the case of $n = 2$ the solution is in a closed form. Numerical results have been carried out for several loading levels and for several geometrical parameters.

From author's summary

609. Olszak, W., and Urbanowski, W., Plane problems of the theory of plasticity of non-homogeneous and anistropic bodies (in English), *J. Sci. Engng. Res. India* **2,** 2, 201-208, July 1958.

Authors discuss plane strain and plane stress for anisotropic and inhomogeneous materials, starting from the plastic potential concept. Particular case of curvilinear orthotropy is investigated. In this case the basic equation for plastic flow in plane strain or plane stress is obtained in terms of the Airy stress function. Simplified form of equations for various types of curvilinear orthotropy is indicated explicitly. Example of orthotropic thick-walled tube is discussed in some detail.

W. T. Koiter, Holland

610. Iljushin, A., On stress-small strain relation in the mechanics of continuous media, Proc. 3rd Congr. Theor. Appl. Mech., Pangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 31-34.

Author considers the general properties of stress and small strain relation in continuous media that in the initial state are quasiisotropic and uniform in the neighborhood of each point. These properties are important for the theory of plasticity under complex loading. Instead of the strain deviator author introduces

a strain vector in a five-dimensional Euclidian space, and theory is analyzed in that formalism.

F. Engelmann, Germany

611. Hodge, P. G., Jr., The collapse load of a spherical cap, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 108–126.

The spherical cap is subjected to uniform internal pressure. Lower and upper bounds on the collapse load are established. The treatment is based on a piecewise linear approximation to the plastic yield condition of the shell. This yield condition may also be thought of as the exact yield condition for an idealized sandwich shell which satisfies Tresca's yield condition. Author takes full account of both circumferential and longitudinal direct forces and bending moments. Two cases are exhaustively discussed: the circumference of the spherical cap is simply supported, and rigidly clamped, respectively.

J. Barta, Hungary

612. Wilhoit, J. C., Jr., Elastic-plastic stresses in rings under steady state radial temperature variation, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 693–700.

The plane stress case of an ideally plastic ring subjected to temperature gradient is considered. It is shown that a temperature gradient of sufficient magnitude causes initial yielding at the inner surface if the Tresca yield theory is employed. If thermal gradient becomes large enough, a second plastic region begins to form at the outer surface and moves inward.

The larger the ratio of outer to inner radius, the lower the temperature gradient required for yielding at the inner surface and the higher the gradient required for yielding at the outer surface.

Theoretically an infinite temperature gradient is required for the ring to become fully plastic.

J. Valenta, Czechoslovakia

613. Weiner, J. H., and Huddleston, J. V., Transient and residual stresses in heat-treated cylinders, *ASME Trans.* 81E (*J. Appl. Mech.*) 1, 31–39, Mar. 1959.

This paper is largely an analytical approach to the problem using the theory of plasticity for both solid and hollow cylinders. The equations which are derived are on the basis of the Tresca yield condition and with a Poisson ratio of one half. For most temperature distributions it is necessary to use numerical integration to solve the equations. However, for one particular temperature distribution which occurs with a fixed-temperature heating or cooling fluid, the equations can be integrated analytically to obtain expressions for the transient and residual stresses. This solution is made in the paper as an indication of the application of the process to calculations of stresses which exist in cylinders during a heat-treatment process. Results of the analytical solution of this particular case are compared with experiments performed twenty-five years ago in Germany. There is reasonable agreement between the two results. Probably closer agreement would be obtained if the experiments were made with the same conditions as were used in the calculations.

G. R. Fusner, USA

614. Aboav, D. A., Final report of research on crystal plasticity, AFOSR TR 59-27 (Univ. Palermo, Inst. Phys. Final Rep.; ASTIA AD 212 257), 24 pp., Jan. 1959.

Introducing an additional parameter of the "state" of the lattice element, author expresses the total internal energy of crystal. Then he deduces the concept that in the configuration of minimum free energy the states would not be randomly distributed but would form an ordered configuration of spherical zones, i.e. "secondary structure." Author attempts to explain the phenomena of critical stress, work hardening, etc., in terms of an increase in the internal energy of the crystal due to the disturbance of this secondary structure caused by, for instance, simple glide.

From this proposed new theory, he found that, within a certain range of purity, the critical shear stress should increase as the cube root of the concentration of impurity. Then he studies experimental result on hardness of metal and got the following empirical rules:

$$H = 1/20 \cdot G/n, \qquad H_s \propto G^{\frac{1}{2}}$$

where H is Brinell hardness number, H_s scratch hardness, G shear modulus, n number of glide direction. He also discusses the distinction between the indentation hardness and the scratch hardness: When the grain size is reduced by crystal break-up, the indentation hardness which depends on the yield stress of metal increases because of smaller grain size, but the scratch hardness which depends on the fracture stress does not increase, for the secondary structure is not affected by the process.

Lastly he applies his theory to the phenomenon of fatigue and concludes that under the cyclic stressing the irreversible changes in the secondary structure take place, so a metal can not withstand a stress as high as under static load.

T. Kanazawa, Japan

615. Ivlev, D. D., On the general equations of the theory of ideal plasticity and of statics of granular (pulverulent) media, *Appl. Math. Mech.* (*Prikl. Math. Mekh.*) **22,** 1, 119–128, 1958. (Reprint order no. PMM 8, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

With the Tresca-Saint Venant condition of plasticity, the condition of isotropy, and the condition of incompressibility, the fundamental equations of equilibrium are shown to be statically determinate when plastic stresses correspond to an edge of the limiting prism in the space of principal stresses.

The general equations for granular media, which are governed by Coulomb's law, are shown to be statically determinate when stresses are on a face of the limiting pyramid in the space of principal stresses.

T. Mogami, Japan

616. Maksimov, S. K., The plasticity of red copper ore (in Russian), Strength of metals, Moscow, Akad. Nauk SSSR, 1956, 139–143; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7189.

Author is of the opinion that the new criterion of creep-deformation resources [see: V. S. Ivanova, *Zavod. Lab.* **21,** 2, 212–216, 1955] is applicable to red copper ore at high temperatures; in highly plastic metals, in the initial moments of loading, large deformation is observable with lowered values for the plastic resources. With high temperatures the red copper ore changes over to the brittle state.

From author's summary

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

617. Zel'dovich, Ia. B., and Raizer, Iu. P., Physical phenomena that occur when bodies compressed by strong shock waves expand in vacuo, *Soviet Phys.-JETP* **8,** 6, 980–982, June 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **35,** 1402–1406, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The glow of an initially solid opaque body that appears after its compression by strong shock wave with subsequent expansion into a vacuum is studied. Condensation of the vapor of the substance and recombination of ions and electrons under these conditions are also considered.

From authors' summary by W. Prager, USA

618. Koistinen, D. P., and Marburger, R. E., A simplified procedure for calculating peak position in x-ray residual stress measurements on hardened steel, *Trans. Amer. Soc. Metals* **51,** 537–555, 1959.

In the measurement of residual stresses in hardened carbon steels by x-ray diffraction, the principal difficulty encountered is the accurate location of the broad asymmetrical diffraction peaks. A simplified correction procedure based on the theoretical factors which affect diffraction peak symmetry is described.

The experimental diffractometer conditions used are those described by Christenson and Rowland with the modification that the Geiger counter and receiving slit are moved to the new focusing positions for ψ angles other than zero. Under these experimental conditions, it is shown that the asymmetry of the broad diffraction peaks is largely due to θ-dependent intensity factors. Thus for the $\psi = 0$ degree data, the Lorentz-polarization factor is used as a multiplicative correction factor. For the $\psi = 60$ degrees data, the multiplicative correction factor is made up of both the Lorentz-polarization factor and a geometrical absorption factor ($1\text{-tan } \psi \cot \theta$).

Having corrected for θ-dependent factors, the peak position is determined by fitting a parabola to the peak using a simplified procedure. Correlations of the stresses measured by this technique with the stresses measured by the Christenson and Rowland technique and by a mechanical dissection technique are shown.

From authors' summary

Rods, Beams and Strings

(See also Revs. 599, 601, 604, 648, 654, 665, 668, 686, 708, 750, 781)

619. Nosek, S., Mathematical analysis of the collective strain of yarns (in German), *Faserforsch. Textiltech.* **9,** 12, 551–557, Dec. 1958.

Of the two possibilities of the skein test, viz. the test without fixing in the filaments firmly (skein test) and with firmly fixed filaments (harp test), the latter gives more accurate and less deviating results. By means of the two-dimensional correlation, formulas are derived for the calculation of the skein strength and, finally, approximate relations for it are given.

From author's summary

620. Sattler, K., Considerations on beam grids having edge beams differing in stiffness from the intermediate beams (in German), *Bauingenieur* **34,** 1, 1–9, Jan. 1959.

Paper extends previous solutions for beam grids with all longitudinal beams equal to beam grids having edge beams of different stiffnesses than the intermediate beams. The method is an approximate one and is intended primarily as a simple practical method of analysis. It is illustrated by means of a number of numerical examples.

Paper draws heavily upon a 1955 paper of the author [AMR **9** (1956), Rev. 2906], even to such an extent that symbols and important functions used are not explained.

F. J. Plantema, Holland

621. Popov, I. G., Calculation of beam systems on elastic supports (in Russian), *Nauchn. Trudi Leningrad Inzh.-Stroit. In-ta* no. 23, 5–27, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1082.

A calculation is given of a system of crossing beams subjected to a transverse load and without taking torsion into account. Systems of equations are formed and means are given for simplification of solutions in some particular cases having practical interest.

S. N. Nikiforov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

622. Guralnick, S. A., Shear strength of reinforced concrete beams, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 1 (*J. Struct. Div.*), 1–42, Jan. 1959.

Paper awakes the design fraternity to the fact that shear failure is an important investigation which must be considered in any ultimate value of a concrete beam. Also, this paper is a contribution to the area of analysis particularly when shear or bond controls the design of a member.

Writer does not agree that tensile strength of a beam is really important to a practicing designer. This may be because the uses of shear control in design may not occur too frequently. Frankly, in teaching concrete theory, tensile strength is not dwelt upon to any extent in the classroom.

In (e) of the summary the Author has left us with "no rational theory for predicting strength of beams with web reinforcement." This is usually the case in analysis and design.

This investigation is a contribution to the analysis of all concrete members by ultimate theory.

W. T. Daniels, USA

623. Swihart, G. R., Allgood, J. R., and Shaw, W. A., Elastic resistance of reinforced concrete beams, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 1 (*J. Struct. Div.*), 43–63, Jan. 1959.

The Engineering Design group is grateful for the paper on resistance (elastic) to loads by reinforced-concrete beams. The answer as given is for simply supported beams; there is need for the answer to continuous beams.

It is expected that nonsymmetrical loading conditions will be studied in the future.

The investigators are to be congratulated upon the instrumentation which showed a satisfactory check between theoretical values and the recorded experimental values.

This investigation is timely in view of the fact that the practice of ultimate design theory is, perhaps, now in common use in America today.

W. T. Daniels, USA

Plates, Shells and Membranes

(See also Revs. 584, 586, 587, 589, 597, 611, 612, 649, 655, 666, 669, 670, 688, 689, 704, 708, 973, 974, 993)

624. Gladwell, G. M. L., Some mixed boundary-value problems of aeolotropic thin plate theory, *Quart. J. Mech. Appl. Math.* **12,** 1, 72–81, Feb. 1959.

This paper applies the theory of sectionally holomorphic functions, developed by N. I. Muskhelishvili and others, to some mixed boundary-value problems of aeolotropic thin plate theory. The mixed boundary conditions are derived from plates having boundaries which are partly clamped, and partly free or subjected to specified bending moment and shear. Each problem is reduced to the solution of a series of equations relating the boundary values of sectionally holomorphic functions on opposite sides of one or more arcs; these are problems solved by Muskhelishvili in "Singular integral equations," 2nd ed., Moscow, 1946. Details are given of the solution for the problem of a plate in the form of the upper half-plane, subjected to constant bending moment and shear on a segment of the real axis, and clamped along the remainder.

From author's summary by E. R. Steneroth, Sweden

625. Ishkova, A. G., On bending of a circular plate and an infinite strip, resting on an elastic half-space (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 87–91, Oct. 1958.

In previous papers author shows that both the problems of bending of thin circular plates and of infinite strip plates resting on elastic halfspace can be reduced to solution of following infinite system of equations with infinite number of unknown coefficients

$$\sum_{n=0}^{\infty} \alpha_{\mu n}(2n - 2m - 1)^{-1} = \beta_{\mu m} \qquad [1]$$

$$(\mu = 1,2\ldots., m = 0,1\ldots..)$$

The solution of system [1] can be expressed in the form

$$\chi_{\mu n} = 2(2n-1)!!/\pi(2n)!! \sum_{s=0}^{\infty} (2s+1)!!\beta_{\mu s}/(2s)!!(2n-2s-1). \quad [2]$$

In the present paper mathematical proof of this last assertion is given.

V. Kovarik, Czechoslovakia

626. Mroz, Z., The load-carrying capacity and minimum weight design of annular plates (in Polish), *Rozprawy Inz.* **6**, 4, 605–626, 1958.

Paper concerns annular plates under axially symmetric load and various support conditions at both edges. As a measure of deformation the rate of curvature variation in the radial and circumferential direction is assumed, the bending moments in these directions constituting the measure of stress. The rigid-plastic model is assumed. The yield condition is assumed in the Coulomb-Tresca form, which is sectionally linear and enables the integration of the equations. It is demanded that the equilibrium conditions and the displacement continuity condition be satisfied in the entire body. For a number of cases considered the results are represented in a clear diagrammatic form.

In the second part the form of annular plates is computed for minimum volume with a given axially symmetric load, assuming that the plastic state is reached in the entire plate.

The relevant variational problem leads to the conclusion that the extremum of volume is assured by the condition of constant mean energy dissipation. This condition gives no certainty, however, that it is a minimum (as was hitherto thought) but there exists a possibility of obtaining a plate with maximum volume. Using the Coulomb-Tresca yield condition the minimum is obtained only for states corresponding to the vertices of the polygon representing this condition.

The considerations are completed by computation examples of the optimum form in three cases of axially symmetric plates with various loads and various support conditions. It is found that the computations are very simple in comparison with the analogous computations of optimum form by other mathematical and physical criteria.

J. Szmelter, Poland

627. Prusov, I. O., The extension of an infinite plate with a circular aperture reinforced by a ring of varying section (in Russian), *Nauch. Zap. L'vovsk. In-ta* **14**, 22–28, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7859.

Author examines the plane problem of the extension of an infinite elastic isotropic plate with a circular aperture to which a collar made of another elastic isotropic material in the form of a ring is soldered; the external outline of the ring is a circle whose radius is equal to that of the aperture; its inner outline is an ellipse. It is assumed that, in addition to tensile forces P and Q applied at "infinity" in a direction parallel to the principal axes of the ellipse, normal forces q are applied, distributed uniformly along the edge of the elliptical opening in the collar. The problem is solved on the basis of the Kolosova-Muskhelishvili theory, and is reduced to finding the two pairs of functions Φ, ψ and Φ_1, ψ_1, of the complex variable $z = x + iy$, which determine the stresses and displacements in the plate and the ring which satisfy the boundary conditions on the contact line and at the edge of the elliptical opening. Conformal transformation is used for the exterior of the single ring, also analytic production and other transformations. The unknown functions of the complex variable are sought in the form of expressions containing power series. An infinite system of recurrent equations is obtained from the boundary conditions for the coefficients of these series. A numerical example is examined; approximate equations are given for the stresses at the contact line and at the outline of the elliptical opening for a plate and a ring with specific elastic constants.

S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

628. Vlasov, B. F., The equations for the bending of plates (in Azerb.), *Dokladi Akad. Nauk AzerbSSR* **13**, 9, 955–959, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7899.

One of the variants of the theory of the bending of plates which are under loads normal to the median surface is set forth, with no direct use of the hypothesis of direct invariable normals. It is assumed that the normal to the undeformed median surface of a plate is distorted when the plate is bent, and that the shears corresponding to this distortion vary by parabolic law through the thickness of the plate. The relative extension along the normal is zero. These assumptions enable the three-dimensional vector for the displacement of points in the plate to be expressed in terms of three functions of the coordinates of the median surface, the bending of the median surface and two angles of rotation of transverse components located on the median surface, in the planes of its normal sections, parallel to the coordinate planes. By averaging the equilibrium equations for a component of an unbroken environment, on the assumption that the tangential stresses on the surface of the shell are equal to zero, and using a certain result of Hooke's law, author obtains a system of three equations defining the functions which are required. The boundary conditions are examined. No examples are given of the application of the theory to actual problems; it is not compared with the theory for thick slabs, nor is the research as a whole analyzed critically.

N. A. Kil'chevskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

629. Shevlyakov, Yu. A., Research into the bending of slightly curved plates (in Russian), *Nauchn. Zap. Dnepropetr. In-ta* **45**, 145–159, 1956; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7900.

The problem of the bending of slightly curved plates is reduced to the successive solution of marginal problems for a biharmonic equation. For this, all the quantities sought (the normal bend u, the force function F, etc.) are resolved into series according to a small parameter which depends on the thickness of the curved plate and the curvature of its surface. The cases of plates fastened and without supports are considered. A numerical example is given for a circular plate bent around a spherical surface and subjected to a uniformly distributed load.

M. G. Slobodyanskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

630. Gumenyuk, V. S., Bending of square plates of variable thickness (in Russian), *Inform. Materialy. In-ta Stroit. Mekhan., Akad. Nauk USSR* no. 10, 57–62, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5728.

An approximate solution is put forward for the problem on the transverse bending of plates, the thickness of which changes according to the linear principle. The method of networks is used. Tables of numbers affecting the calculations are given.

From author's summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

631. Joga Rao, C. V., Long rectangular plates subjected to linearly varying loads, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst., Technol., Kharagpur, 1956, 8–15.

An approximate value of the axial tensile force per unit length has been obtained by considering the given total load as a uniformly distributed load in cases of plates with simply supported edges and plates with fixed ends. The results are applicable to cases where the deflections of the plates are large compared to the plate thicknesses but small compared to the widths.

From author's summary

632. Mohan, M., On stresses in a thin isotropic elastic plate in the form of epitrochoid rotating steadily in its plane, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 95-98.

Stresses due to uniform rotation of a thin elastic plate in the form of epitrochoids have been determined. The region is transformed into the interior of a unit circle, and by an application of Muskhelishvili's method the problem has been reduced to the solution of integral equations for which a solution has been obtained.

From author's summary

633. Chi, M., and Irwin, L. K., Elastic deformations in strips with holes loaded through pins, *J. Res. Nat. Bur. Stands.* **62,** 4, 147-152, Apr. 1959.

Bickley's solutions [*Phil. Trans. Roy. Soc. Lond. (A)* **227,** p. 383, 1928] for an infinite elastic plate loaded by a rigid pin have been superposed on Kirsh's well-known results for a circular hole under uniform unidirectional tension. Numerical examples have been developed and presented in the form of graphs for widely used single-shear test specimens in two typical cases.

S. C. Das, India

634. Thurston, G. A., A numerical solution for thin conical shells under asymmetrical loads, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 171-194.

Author presents a numerical solution for the conical shell equations, based on Langhaar's theory, suitable for a high-speed digital computer. Assuming the external surface loads and the displacements expandable in Fourier's series, the separation of variables yields a set of integral equations later transformed into a set of algebraic equations solved by Gaussian elimination. The boundary conditions are assumed to be linear combinations of the displacements coefficients and of the coefficients of the principal curvature along the generator. A numerical example of a truncated conical shell bent as a cantilever beam is included, and results are checked with the membrane solution, and the asymmetric bending terms with the solution for a plate under a linearly varying load. The numerical solution is not valid near the apex of a complete conical shell.

The numerical program was written for the IBM 704 electronic computer, and results from the program were checked for accuracy against known solutions for special cases of cylindrical and conical shells under axisymmetric loadings. Z. Karni, Israel

635. Haas, A. M., Theory and research in concrete shell design, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 4 (*J. Struct. Div.*), 1-21, Apr. 1959.

Author emphasizes the need for basic research in shell design. He summarizes existing practice in the industry, citing tests carried out at the Stevin-Laboratory of the Technological University of Delft and at other laboratories. A. P. Boresi, USA

636. Reissner, E., On the determination of stresses and displacements for unsymmetrical deformations of shallow spherical shells, *J. Math. Phys.* **38,** 1, 16-35, Apr. 1959.

Elastic shells of uniform thickness are treated. The governing equations are two simultaneous equations for a stress function F and the axial displacement w. Radial and circumferential displacements are expressed explicitly in terms of F and w.

A new type of solution is developed and applied to the discussion of a shell supported at its outer edge and having a symmetrical rigid insert acted upon by a tilting moment and a side force.

A series solution for distributed axial loads is presented. The first term of this series corresponds to the result of membrane theory. As an application, the hydrostatic loading is examined. The conditions under which the state of stress away from the edges is a membrane state or state of inextensional bending are discussed.

No numerical results are presented. R. Schmidt, USA

637. Kornecki, A., On the membrane state of stress in a curved circular tube, *Bull. Res. Council Israel* **5C** (Technology), 3, 197-200, Aug. 1958.

Author investigates type of edge loading which will cause a segment of a toroidal shell to be in a membrane state of stress. The points $\phi = 0, \pi$, where indefinite values result from the usual membrane theory, are considered.

Author concludes that the only possible edge loading leading to a membrane state is statically equivalent to a twisting couple. Other edge loadings cause bending near $\phi = 0, \pi$.

G. D. Galletly, USA

638. Langhaar, H. L., and Boresi, A. P., Strain energy and equilibrium of a shell subjected to arbitrary temperature distribution, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 393-399.

With the usual assumptions of thin shell theory (made by Navier, Kirchoff, Love, etc.), authors derive equations for an arbitrary shell which take temperature effects into account. Their approach differs from the usual [see Hildebrand, Reissner and Thomas, *NACA TN* 1833; AMR **3** (1950), Rev. 453, for a discussion of various possible theories] in that factors of the form $(1 - z/R)^{-1}$ are incorporated in an exact manner (z is the coordinate normal to the middle surface and R is the radius of curvature of the middle surface). Other theories approximate such factors by the first term or two of their expansions in powers of z. The authors note that they had not known of similar results previously published by H. Parkus [*Öst. Ing-Arch.* **4,** (1950); AMR **4** (1951), Rev. 629].

R. A. Clark, USA

639. Nigul, U. K., The calculation of open circular cylindrical shells in transverse trigonometric series (in Russian), *Trudi Tallinsk. Politekhn. In-ta (A)* no. 82, 71-82, 1956; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7877.

The equations for the forces and displacement governed by movements of the curvilinear edges and by the effect of symmetrically distributed normal and tangential loads are written for a short open circular cylindrical shell, all of whose edges are swivel supported. Two variant solutions are obtained: (1) on the basis of the equation for the large variability factors of the stressed state

$$\frac{\delta^2}{12R^2(1-\mu^2)}\Delta\Delta\Delta\Delta\varphi + \frac{\partial^4\varphi}{\partial\xi^4} = 0$$

where δ is the shell thickness, R the radius, μ is Poisson's ratio, ξ and φ are dimensionless coordinates, and Δ is the Laplace operator; and (2) on the basis of V. Z. Vlasov's semi-momentless theory equation. In both cases, a potential function is found in the form of resolution into trigonometric series according to variable φ (a transverse series). Poisson's ratio is taken as zero.

L. M. Kurshin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

640. Metskhovrishvili, Sh. S., The infinitely small bending of a tore-shaped shell (in Georgian), *Soobshch. Akad. Nauk GruzSSR* **18,** 5, 521-527, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7879.

We know that the problem of the infinitely small bending of an elastic momentless shell is reduced to finding the single unknown function V. This function satisfies the equation in partial second-order derivatives; the displacement coefficients can be determined with its aid. The method indicated for solving the problems of infinitely small bends is applied to the case of a tore-shaped shell. It is proved that the displacements in a closed tore-shaped shell are multivalent. In particular, the tangential components of the displacement vector adopt the form:

$$u_1 = al(\varepsilon^2 - 1)\vartheta \sin\varphi$$

$$u_3 = -al(1 - \varepsilon \sin\varphi)\left\{\cos\varphi - \frac{2\varepsilon}{\sqrt{1-\varepsilon^2}}(1 - \varepsilon\sin\varphi)\arctan\right.$$

$$\left.\arctan x\left[\sqrt{\frac{1-\varepsilon}{1+\varepsilon}}\tan\left(\frac{\pi}{4}+\frac{\varphi}{2}\right)\right]\right\}$$

where φ and ϑ are curvilinear coordinates on the median surface, a is the radius of the circle whose rotation forms the tore, l is the distance between the center of the circle and the axis of symmetry, and ε is the tore eccentricity. Two particular cases are examined: (1) the infinitely small bending of a tore-shaped shell whose edges are attached to a plate and (2) where the edges of a tore-shaped bar are gripped. Author reaches the conclusion that only rigid displacements can take place in these cases, i.e. that there is no infinitely small bending. O. D. Oniashvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

641. Hammad, H. Y., Approximate theory of bending of short cylindrical shell roofs, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 1–7.

The application of the general theory of bending of cylindrical shells in even the simplest cases results in very complicated calculations. To make the theory applicable to the solution of practical problems such as encountered in structural engineering, some further simplifications in this theory are necessary. Finsterwalder in 1933 produced an approximate solution for long shells.

In this paper a similar approximation for short shells is attempted. Since, in short shells of uniform small thickness, the moment of resistance of the arch strip is small compared to that of the longitudinal strip, the transversal bending moment may be neglected. From author's summary

642. Peshtmaldzhyan, D. V., The calculation of symmetrically loaded laminated anisotropic rotating shells (in Armenian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Matem. Nauk* **10,** 2, 39–54, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7873.

A thin symmetrically loaded multi-layer rotating shell of zero Gaussian curvature, consisting of an arbitrary number of orthotropic layers, whose planes of elastic symmetry are inter-parallel, is examined. One of these planes is parallel to the outer surfaces of the shell, the other two are perpendicular to the lines of principal curvature. The system of two equations, to which the problem of calculating a shell of this nature is reduced on the assumption that the hypothesis of straight normals is valid for the complete package of a laminated shell, is reduced, for a specific rigidities ratio, to a single equation by the introduction of a complex function [Lur'e, A. L., "The statics of thin-walled elastic shells," Moscow, Gostekhizdat, 1947]. In the case where a shell is cylindrical or consists of isotropic layers, the problem is reduced to a single equation with no additional limitations. A general solution for the homogeneous equation, expressed in terms of two Bessel functions, is written for a conical sheath. The solution for a shell consisting of isotropic layers with different Poisson ratios is indicated as a special case. An example of the calculation is given. A general solution is written for the homogeneous equation for a cylindrical shell. The zone in which the marginal effect is propagated in a laminated cylindrical shell is assessed. Solutions are given to a number of problems for shells of this nature. A numerical example is given of the calculations for a two-layer cylindrical shell. L. M. Kurshin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

643. Huddleston, J. V., and Salvadori, M. G., Moments in domes built into cylinders, *Trans. Amer. Soc. Civ. Engrs.* **122,** 235–248, 1957.

When a thin shell of revolution is constructed integrally with a circular cylinder, symmetrical loading produces significant flexure near the junction. With architectural applications in mind, authors develop an approximate analysis for these bending moments in the usual case where the dome makes a smooth transition to the cylinder. The essential simplification is provided by the Geckeler assumption that the portion of the dome at the knuckle may be replaced by a cylinder. Then edge moments and shears needed to remove the discontinuity in displacement and rotation predicted by elementary membrane theory are calculated.

The results are presented in a form which facilitates their use by structural designers. L. E. Goodman, USA

644. Durelli, A. J., Dally, J. W., and Riley, W. F., Stress and strength studies on turbine blade attachments, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 171–182, 1958.

The objective of this paper is to illustrate the manner in which a number of experimental techniques have been used in an integrated approach to the solution of the problems in turbine and compressor blade attachments. Experimental methods employed include brittle coatings, photoelasticity, ordinary and high-temperature electrical-resistance strain gages, and a fatigue testing assembly. Various phases of the following problems are presented: (1) transmission of the forces from the airfoil into the dovetail joint, (2) optimization of the dovetail fillets, (3) influence of the protuberance angle, (4) influence of simultaneity of protuberance contact, (5) determination of protuberance loading, (6) high-temperature fatigue testing.

Due to the general nature of this paper emphasis has been placed on the application of the experimental methods and, in many instances, the results of a particular investigation have been deleted. From authors' summary

645. Angell, B. S., and Paslay, P. R., Determination of the stacking strength of corrugated fiberboard containers, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 109–116, 1958.

The results of analytical and experimental studies to determine the short-time, top-to-bottom compressive load-carrying capacity of commercial corrugated fiberboard containers are presented here. An analytical procedure to predict failure loads and evaluate design changes for containers of large panel dimensions was developed. An experimental technique using SR-4 strain gages was also developed to verify the panel load distribution assumed in the theoretical analysis. To correct for the tendency of SR-4 gages to stiffen the fiberboard locally, reinforcement factors for each of the two principal directions of the fiberboard were determined. Comparison of analytical and experimental results are encouraging and indicate that corrugated containers can be designed and tested in a manner similar to other elastic structures in engineering.

From authors' summary

646. Borcz, A., Plates with stiffening beams (in Polish), *Rozprawy Inz.* **6,** 3, 351–406, 1958.

Paper concerns the action between the plate and the stiffening beams. Author assumes curvilinear beams and establishes equations for deformations of the plate and the beam, Kirchhoff's hypothesis of indeformable normal and that of plane sections being assumed for the plate and the beam, respectively. From the condition of compatibility of displacement, relations are obtained between the mechanical quantities in the beam and in the plate. In the general case the author obtains six conditions, which are then reduced to four. In particular cases he obtained the known equations based on the condition of compatibility of displacements.

In conclusion examples of rectangular beams reinforced with beams along the external edges are discussed.

Z. Mroz, Poland

647. Tseilin, Sh. Yu., The joint working of overlapping panels (in Russian), Research into the theory of structures no. 7, Moscow, Gosstroiizdat, 1957, 521–531; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7919.

The task is reduced to the calculations for a system of plates freely supported at the two parallel sides and hinge-jointed for transmitting the reactions of the supporting outline. The solution to the problem is given in the M. Levi form, the load at the plate edge being the unknown. Graphs are given to simplify calculations. A. A. Kurdyumov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

648. Thurlimann, B., Influence surface for support moments of continuous slabs, *Publ. Int. Assn. Bridge Struct. Engng.* **16,** 485–498, 1956.

Pucher's theory ["Einflussfelder elastischer Platten," Springer, Vienna, 1951] of influence function has been extended to the case of continuous plates. An expression has been obtained for bending moment over a rigid cross beam across a simply supported plate strip in closed form. Solutions for infinite plate strip with two rigid cross beams and for two-span continuous plate have also been derived and rapidly converging nature of the series solutions has been demonstrated. Graphical representations are given for these specific examples. S. C. Das, India

Buckling

649. Pfluger, A., Thin-walled compression members, AFOSR TN 59-291 (Inst. Statik, Tech. Hochschule, Hannover Rep. 1; ASTIA AD 212 923), 37 pp., Dec. 1958.

Paper treats buckling problems of centrally loaded columns. It is essentially a review of German practice, emphasizing buckling in the elastic range. Pure flexural buckling, torsional-flexural buckling, local buckling, and coupling are considered and design charts are presented for a variety of thin-walled shapes. Report no. 2 promises to deal with the plastic range and postbuckling behavior. J. A. Cheney, USA

650. Steinbach, W., Contribution to the stability of a cantilever beam (in German), *Bauingenieur* **33,** 11, 414–419, Nov. 1958.

Paper deals with the lateral elastic stability of a cantilever of narrow rectangular cross section loaded by a transversal and a normal force at the free end. The solution of the known differential equation of the problem is sought in the form of a power series. Tables and diagrams illustrate the results of calculations. D. Radenkovic, Yugoslavia

651. Fel'dman, M. R., The stabilities of rods of variable section (in Armenian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Matem. Nauk* **10,** 4, 19–28, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8121.

The Bubnov-Galerkin method and the method of finite differences are used for investigating the stabilities of straight compressed rods. The differential equation for the curvilinear form of equilibrium in a compressed rod is replaced by a finite difference equation. An approximate solution is sought in the form of one or several terms of the resolution of the curvilinear form equation into series according to fundamental functions satisfying all the boundary conditions of the problem. Use of the Bubnov-Galerkin method results in a system of homogeneous linear equations relative to the parameters of the terms in the series which are used. The critical load value is determined by equating the determinant formed from the coefficients of this system of equations to zero. It is important that the order of the determinant depends not on the number of points at which the interval is divided, but on the number of terms in the resolution to series which are used. The stability of a two-step rod with hinge-supported ends, the rods loaded by compression forces such that the point where the section alters abruptly coincides with the site of the corresponding change in the ordinates of the normal forces diagram, is taken as an example for the use of the proposed method. Tables are given for the critical combination of applied forces, with relation to the ratio between the moments of inertia and rod section lengths. Comparison of some of the results obtained with data from F. S. Yasinskii's accurate solution ["Collected works on the strengths of rods under compression," Gostekhizdat, 1952] proves that there is little enough divergence between the critical force values compared. The strengths of three- and five-step symmetrical rods under a constant compressive force are also examined. The numerical example of calculation of the reinforcement of a compressed rod for part of its length is given. V. M. Makushin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

652. Svirskii, I. V., The question of derivation of variational formulae for the problem of stability (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Matem. i Tekhn. Nauk* no. 10, 41–49, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5713.

A deduction is given of the equations of the Bubnov-Galerkin method for the problems of stability of an elastic system, if the approximating functions do not satisfy all the geometrical boundary conditions. The basis of the deduction is the requirement that the first variation of critical loads when the approximating functions change should be converted to zero value. Using this idea the following results are obtained. Let the critical condition of the elastic system be described by the equations

$$X(u, p) = 0 \qquad [1]$$

$$X_1(u, p) + K(u, p) = 0 \qquad [2]$$

where [1] represents in itself the equation of the elastic system, Eq. [2] represents the boundary conditions, where $K(u, p)$ are the reactions of the elastic bonds, p is the parameter characterizing the magnitude of the load. In order to determine the critical load the following equation is derived

$$\int_{v_0} \varphi_0 X(\varphi_0, p_{kp})\,dv + \int_{\Gamma} \varphi_0 [X_1(\varphi_0, p_{kp}) + K(\varphi_0, p_{kp})]\,ds = 0 \qquad [3]$$

where φ_0 though approximating the actual solution does not necessarily satisfy all the boundary conditions. It is shown that formula [3] gives a good result provided the bond is not too rigid. In the case of bonds with significant rigidity, author recommends the use of the following variational equation

$$\int_{v} \varphi_0 X(\varphi_0, p_{kp})\,dv + \int_{\Gamma} \varphi_0 X_{\Gamma}(\varphi_0, p_{kp})\,ds - \int_{\Gamma'} \psi_0 X_{\Gamma}(\varphi_0, p_{kp})\,ds = 0 \qquad [4]$$

where Γ' is part of the boundary where elastic bonds are functioning, while ψ_0 is determined by the equation

$$K(\psi_0, p_{kp}) = -X_{\Gamma}(\varphi_0, p_{kp}) \qquad [5]$$

On the basis of correlation [4] the author gives a method with whose aid it is possible to compute the influence of the elasticity of the supports on the critical load. The developed theory is applied to the problem of the stability of a not too long cylindrical shell on the assumption that it is connected by the ends to a round frame. It is assumed that the shell is subjected to the action of external pressure and axial compression. The critical loads are calculated to meet two eventualities: on the assumption

that the frame is not extensible, and taking into account the extensibility. A corresponding transition coefficient is deduced.

I. I. Vorovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

653. Clark, L. G., General small deflection theory of elastic bending and buckling of laminated plates, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 127–151.

Equilibrium equations are derived for thin elastic laminated plates subject to small deflections. Boundary conditions are based on assumptions that there is no relative motion at the joining lines or points and shear deformations are neglected. Because the boundary conditions of a laminated plate differ from a corresponding solid plate, author introduces so-called internal boundary conditions that depend upon the nature of the joints used to form the laminations. By use of these internal boundary conditions, solution of bending and buckling problems is similar to that used for thin plate theory. Good agreement is indicated between theory and experiment for two special cases investigated.

G. Gerard, USA

654. Mansfield, E. H., On the post-buckling behavior of stiffened plane sheet under shear, *Aero. Res. Counc. Lond. Rep. Mem.* 3073, 21 pp., 1958.

Paper concerns very thin plane sheets stiffened by stringers and frames, the latter being not attached directly to the sheet. The behavior of such sheets under high loads was first explained by H. Wagner.

By an approximate analysis author extends the work by Kromm and Marguerre [*Luftfahrt.-Forschg.* **14,** p. 627, 1957] to cases in which the frames and the stringers have any compressive stiffness.

Formulas and graphs for the rapid determination of the shear stiffness and the shear strain of the sheet as well as of the stresses in the stringers and the frames are presented.

A. Werfel, Israel

655. Marciniak, Z., An analysis of the stability of a thin-walled shell subjected to tension in the plastic state (in Polish), *Rozprawy Inz.* **6,** 4, 529–535, 1958.

The problem under consideration is that of stability loss of a thin-walled cylindrical shell subjected to the action of an internal pressure and a tension. Although in uni-axial tension of a test-piece the stability loss is manifested by the appearance of a neck, it is possible here that, in addition, a local convexity or concavity appears.

Expressing the condition of stability loss, author considers an example assuming the strain-hardening curve in the form of the diagram for mild steel. It is found that with a proportional state of strain after stability loss the extremum of the axial force does not coincide with that of pressure. The calculation results are represented in diagramatic form.

Z. Mroz, Poland

Vibrations of Solids

(See also Revs. 690, 691, 695, 775, 993, 1027)

Book—656. Panovko, Ya. G., Bases for the applied theory of elastic vibrations (in Russian), Moscow, Mashgiz, 1957, 336 pp. + illus. 11r.45k; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6976.

Book reflects the contemporary state of the theory of elastic vibrations applicable to the problems of machine construction; references are made to recent publications and to some investigations carried out by the author. The first part of the book deals with systems possessing one degree of freedom. Chapter 1 is dedicated to a discussion on free vibrations; a good deal of attention is given to approximate methods for introducing the system with one degree of freedom: the energetic method, the method of resolution to the simplest system and the method of successive approximations. Constrained vibrations form the subject matter of Chapter 2; the subject is discussed for the cases of absence of inelastic resistances as well as of their presence. In Chapter 3 a description is given of the vibrations of elastic nonlinear systems. When working out solutions for the problem of free vibrations an examination is made of the known approximate methods [the Lyapunov-Lindstedt method, the Bubnov-Galerkin method, the method of harmonic linearization evolved by N. M. Krylov and N. N. Bogolyubov], and a method is also demonstrated for the minimization of the "suspended" quadratic declination (covering both the symmetrical and unsymmetrical variants) in problems of elastic vibrations, this method being presented by the author. The last chapter in the first part of the book, Chapter 4, deals with quasi-harmonic vibrations and autovibrations. A concrete investigation is made of the transverse vibrations of a cantilever beam, compressed by a longitudinal force changing with time in accordance with the echelon principle, of the parametrical resonance during vibrations of some system in tension, of the vibrations of a crankshaft mechanism, and a description is given of methods for examining frictional vibrations. In conclusion a short investigation is made of autovibrations produced during the cutting of metal.

The second part of the book, with three chapters, is devoted to a study of systems possessing several degrees of freedom. Chapter 5 analyzes free vibrations. The form of exposition follows customary practice. Chapter 6 concerns the theory of constrained vibrations. The last chapter, 7, of the second part deals with investigations on the transverse vibrations of rotating shafts (the critical velocity of rotation, the influence of friction, the influence of the lubricant film in the bearing, the case of a rigid rotor in elastic bearings, the automatic balancing of rotating shafts).

The third and last part, with two chapters, consists of investigations of systems with continuously distributed mass. Chapter 8 contains an examination of the free vibrations of beams. An investigation is also included of the free vibrations of beams of variable section, with an exposition of the known approximate methods of solution of this problem. At the end of the chapter a short explanation is given on the plane vibrations of disks, on the deflection vibrations of disks and on approximate methods for the deflection vibrations of rectangular plates. Chapter 9 very briefly deals with an examination of constrained vibrations.

N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

657. Caughey, T. K., Whirling of a heavy chain, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 101–108.

Paper concerns approximate solutions for the nonlinear problem. Proceding from the motion equations of a heavy chain, author discusses the steady state of the whirling in a rotating coordinate system, performing first the linearization of equations. Results are used for the nonlinear problem, and quite accurate solutions are obtained. Special attention is given to the stability of steady-state solutions. The mathematical computations involve the use of Bessel functions and results are comparatively plotted in diagrams. It is shown that for a given mode triple-valued solutions are obtained for speeds of rotation above the linear critical speed for that mode, out of which two are stable and the third is unstable.

Reviewer believes that paper is a valuable contribution to the subject.

C. S. Pelecudi, Roumania

658. Fettis, H. E., Note on the determination of higher modes of vibration by the Stodola or matrix-iteration method, *J. Aero/Space Sci.* **26,** 5, 317–318 (Readers' Forum), May 1959.

In matrix-iteration process, deflected form converges to lowest frequency mode; in order to find second mode the lower mode is found first and second mode is then found by "sweeping" first mode component from trial deflection. In author's method only knowledge of lowest frequency is required instead of that of modal shape; further, a very accurate knowledge of the frequency is not called for. Method appears to be a useful advance on earlier process and deserves attention.

D. C. Johnson, England

659. Holste, W., Generalization of Stodola's approximate method for the calculation of natural frequencies (in German), *Forsch. Geb. Ing-Wes.* **24,** 4, 118–124, 1958.

The method of the title is applied graphically and analytically, using matrix algebra, to several specific vibration problems.

G. Herrmann, USA

660. Fettis, H. E., Extension of the Stodola method to composite Sturm-Liouville equations (in English), 8th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 434–442.

Author gives a very effective method of integrating equations of the type

$$\frac{d^2}{dx^2}\left(P\frac{d^2y}{dx^2}\right)+\frac{d}{dx}\left(Q\frac{dy}{dx}\right)=\omega^2Ry,$$

which one may have to deal with in the theory of transverse vibrations of rotating shafts. His method consists in a change of the unknown variable after one integration. The equation is then reduced to the form

$$\frac{d}{dx}\left(P\frac{dU}{dx}\right)+QU=\omega^2\int_0^x Rydx=F(x).$$

We have to assume the first approximation of the solution $y = y(x)$, thus obtaining on the right side of the last equation the approximate term $= F(x)$. Denoting by $\bar{U}$ a particular solution of the homogeneous equation for U, the general solution for U in the next approximation is

$$U=C_1\bar{U}+C_2\bar{U}\int_0^x\frac{d\bar{x}}{P\bar{U}^2}+\bar{U}\int_0^x\frac{d\bar{x}}{P\bar{U}^2}\left[\int_0^x F\bar{U}dx\right]$$

which gives at once the solution for y. The functions $P(x)$, $Q(x)$ and $F(x)$ need not be given explicitly, but may be prescribed with tables or curves. A numerical example and a comparison with older methods are added.

J. S. Naleszkiewicz, Poland

661. Ivovich, V. A., Contribution to the problem of forced pseudoharmonic oscillations of rods on elastically compliant supports, *Soviet Phys.-Doklady* **3,** 2, 426–430, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **119,** 1, 42–45, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Title problem leads to a differential equation with two small nonlinear terms, the first proportional to the displacement cubed and the second proportional to the displacement times the second derivative of its square. Solution in terms of known functions does not exist. Known approximate methods require amplitude to be small and become very involved when high accuracy is required.

Author proposes a new approach to problem. He replaces the harmonic external force by one having the same shape in time as the natural oscillations. The equation then has an exact solution in terms of elliptic functions. It happens that the function approximating the actual forces is very nearly sinusoidal and, for this reason, author's solution is sufficiently accurate for practical application when the amplitude is small, or for all values of the amplitude when the disturbing force is small.

P. C. Dunne, Brazil

662. Ivovich, V. A., Subharmonic oscillations of rods with nonlinear inertia, *Soviet Phys.-Doklady* **3,** 2, 434–437, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **119,** 2, 237–240, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author considers the nonlinear differential equation approximating the forced transverse vibrations of an elastic rod the support at one end of which is free to move axially and carries a mass. It is shown theoretically that under certain conditions ultraharmonic or subharmonic resonance may occur. An experiment is described in which a subharmonic oscillation of order 1/2 was obtained.

P. C. Dunne, Brazil

663. Wieckowski, J., The influence of material damping on nonconservative reactions of elastic beams during torsional and longitudinal vibrations (in English), *Arch. Mech. Stos.* **10,** 4, 479–497, 1958.

The stress-waves due to forced vibration provoke, in an elastic medium, reactions depending on the type of the external force and the elastic and geometrical quantities of the system. These reactions have the character of viscous friction forces and, therefore, they are nonconservative with constant coefficient λ. The influence of material damping on the values and properties of these reactions in the case of longitudinal vibration of beams and coil springs is taken into consideration. For torsional vibration of an infinite beam an approximate equation is obtained for the coefficient λ, material damping being taken into consideration, its influence in this case being insignificant.

For beams of finite length there exists a certain characteristic frequency of forced vibration above which the material damping may be disregarded. For real frequencies of external force these lengths prove to be very great.

Analogous considerations for longitudinal vibrations of coil springs reduced to equivalent beams show that the lengths above which they may be considered to be infinitely long for the computation of λ lie within the limits of practical dimensions.

M. Piatek, Poland

664. Kaliski, S., The dynamic non-steady axially symmetric problem of a cylinder (in English), *Arch. Mech. Stos.* **10,** 6, 793–810, 1958.

The problem of forced nonsteady vibration of a full cylinder, fixed or free, is solved, the field of vibration exciting mass forces being axially symmetric.

Both cases may be solved in a similar way, therefore the solution is given only for fixed walls. The general spatial problem is to be treated in a separate paper.

The problem is solved by introducing author's dynamic displacement function and reducing the problem to the solution of two independent "bi-wave" equations in cylindrical coordinates. The equations are subjected to the Laplace transformation. A basic system is assumed with boundary conditions such that the solutions may be represented by means of relatively simple complete sets of functions. To realize the boundary conditions of the initial problem, reactions on the surface of the cylinder are introduced. The determination of these reactions was performed by deriving a system of three integral equations depending additionally on the parameter p of the Laplace transformation. The field of vibration-provoking forces is resolved into two: symmetric and antisymmetric in relation to the symmetry plane of the cylinder normal to the axis. After this resolution two independent systems of integral equations are obtained for each of the component fields. In view of the analogy of the two systems, only one of them is solved, assuming a suitably chosen form of solutions, thus ob-

taining instead of the integral equations an infinite system of algebraic equations containing the transformation parameter p. Next, full regularity of this infinite system of equations is proved, thus proving the existence and the uniqueness of the solutions and, therefore, the convergence of the iterations in approximate calculations.

The solutions containing the transformation parameter p must now be retransformed, which is mentioned only in a brief manner. Finally, a brief discussion is given of vibrations forced by a field of periodically variable forces.

J. Naleszkiewicz, Poland

665. Bufler, H., and Hahn, H. G., Critical speeds and bending vibrations of continuously loaded shafts with variable supports (in German), *Ing.-Arch.* **26**, 6, 387–397, Dec. 1958.

Paper analyzes in detail the case of bending vibrations and critical speeds of continuously loaded shafts when the effect of inertia moments of elements is taken into account. In comparison with the unaffected case, the natural frequencies of bending vibrations decrease, while the critical speeds influenced by elementary gyroscopic moments increase or decrease as the synchrone or asynchrone precession takes place.

Authors investigate four typical cases of end conditions and present detailed diagrams enabling an easy determination of affected natural frequencies for the four lowest natural values. Approximate formulas for higher modes are developed.

Results show that the variation of critical speeds may be of practical interest in special cases. Paper is easy to follow and of practical importance. K. Julis, Czechoslovakia

666. Bycroft, G. N., Frequencies of a flexible circular plate attached to the surface of a light elastic half-space, *ASME Trans.* **81C** (*J. Appl. Mech.*), 1, 13–17, Mar. 1959.

Expressions are obtained for the approximate fundamental frequency of free vibration of a thin circular plate attached to the surface of a massless elastic half-space. Specific edge conditions for the plate considered are: (1) Zero displacement and slope: (2) zero displacement and moment; and (3) zero moment and shear.

A Rayleigh-Ritz procedure is used to determine the fundamental frequency by means of the expressions for the kinetic energy of the plate and potential energies of the plate and half-space for the conditions of common displacement between the plate and the half space over the plate area. M. V. Barton, USA

667. Narasimhamurthy, P., The effect of transverse shear deformation and rotary inertia in wave propagation and vibration of thin elastic plates, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 351–360.

Author presents a set of approximate equations of flexural motion for thin elastic plates. Derivation—following a usual method—is based on assuming hypothetical displacements which are expressed as the sum of the classical plate displacements plus such correction terms so that the derived stresses satisfy boundary conditions on the faces of the plate. Author points out that, in the resulting equations of motion, the terms involving the density of the material take care of rotary inertia and those involving the shear modulus take care of transverse shear deformation. Reviewer believes such statements ought to be drawn more clearly, as the accuracy of the conclusions is not discussed. To illustrate the approach, equations are applied to an infinite plate. Results obtained are in accordance with those already known. H. C. Reggini, Argentina

668. Veletsos, A. S., and Newmark, N. M., Natural frequencies of continuous flexural members, *Trans. Amer. Soc. Civ. Engrs.* **122**, 249–285, 1957.

Authors present an iterative numerical procedure for determining the natural frequencies of flexural vibration of uniform continuous beams on rigid supports and for uniform plane frameworks without sidesway.

The method utilizes modified moment distribution concepts and is based upon the classical observation that in the absence of damping, the exiting forces or couple needed to maintain a structure in a state of forced vibration with finite amplitude are equal to zero when the frequencies of the load are equal to a natural frequency of the structure.

Necessary elastic property tables are included as well as several illustrative problems. S. F. Borg, USA

669. Yangurazov, Sh. Kh., Determination of the frequency of the natural vibrations of part of a shell of double curvature (in Russian), *Sb. Nauchno-Issled. Rabot Tasbkentsk. Tekstil'n. In-ta* no. 4, 211–216, 1957; *Ref. Zb. Mekh.* no. 6, 1958, Rev. 6962.

The determination described in the title was made with the aid of the Rayleigh and Lagrange methods. Approximate solutions are given for a shell of double curvature, elastically closed along the contour, and for a shell rigidly closed along one edge and freely open along the other. The frequencies were determined of the basic tone of an arch of the "Uzbekstan" type with radius for the large span of 15 m and for the small span of 1.5 m.

O. D. Oniashvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

670. Goldberg, J. E., Axisymmetric oscillation of conical shells (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 333–343.

The equilibrium equations for an infinitesimal surface element are combined with force displacement relationships for thin shells to give second- and fourth-order differential equations for axisymmetric motions. Assuming periodicity and shifting the origin from the apex (a singularity) to the outer edge, power series solutions can be determined involving distance from the edge as variable. Six boundary conditions determine constants and eigenvalues for free oscillations. Calculations of three natural frequencies and modes for a typical loud speaker conical frustum are presented.

E. T. Welmers, USA

671. Weidman, D. J., and Kordes, E. E., Experimental influence coefficients and vibration modes of a multispar 60° delta wing, NASA Memo 2-4-59L, 28 pp., May 1959.

Test results are presented for both symmetrical and antisymmetrical static loading of a wing model mounted on a three-point support system. The first six free-free vibration modes were determined experimentally. A comparison is made of the symmetrical nodal patterns and frequencies with the symmetrical nodal patterns and frequencies calculated from the experimental influence coefficients. From authors' summary

672. Schnittger, J. R., Development of a smooth-running double-spool, gas-turbine rotor system, *ASME Trans.* **81A** (*J. Engng. Power*), 2, 151–160, Apr. 1959.

Bearing instabilities in a particular gas-turbine plant are discussed. A theoretical treatment of shaft and bearing performance based on the work of previous investigators is applied and the results are compared with experimental findings.

E. Saibel, USA

673. Brewer, G. A., Vibration analysis of a 700-horsepower induced draft fan, *Proc. Soc. Exp. Stress Anal.* **16**, 1, 17–26, 1958.

Paper describes tests run to determine the causes of destructive vibration of a 700-horsepower induced draft fan in a motor-magnetic clutch-fan installation. Fracture of the Falk Steelflex coupling

between the clutch and the fan was traced to the design of the clutch, which had a symmetrical 24-pole field. Subsequent modification to incorporate an unsymmetrical 29-pole field eliminated the fracturing. From author's summary

674. Edel′, Yu. U., and Stepanov, A. P., The influence of water on the vibration frequencies of the blades and the plates (in Russian), Hydroturbine construction **4**, Moscow-Leningrad, Mashgiz, 1957, 138–144; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6495.

An experimental investigation of the changes of vibration frequencies in the blades of hydroturbines in relation to the density and viscosity of the medium in which the vibrations are taking place. Thus the vibration frequency of a blade in water is 20–40% less than the vibration frequency in air. The more rigid the blades the smaller the diminution of vibration frequency. Changing the velocity of the flow of water from 0 to 3 mps has practically no effect on the vibration frequency.

B. A. Kulagina
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

675. Bisshopp, K. E., Forced torsional vibration of systems with distributed mass and internal and external damping, *ASME Trans.* **81**E (*J. Appl. Mech.*), 1, 8–12, Mar. 1959.

This analysis extends similar results previously obtained in a paper by Den Hartog and Li [*Trans. ASME* **68**, 276–280, 1946], where the remainder torque is calculated at one end of a homogeneous system. Comparative computations made there with complex Holzer tables show excellent agreement with results obtained from the theory of distributed systems. The general boundary-value problem, including the response to an externally applied torque at any section, is solved in this paper. The special case of a homogeneous engine system with a flywheel at one end is analyzed in detail. The theory is illustrated with comparative computations using complex Holzer tables for such a system with external torque applied at a section remote from the ends. Again, numerical results obtained by both methods are in excellent agreement. From author's summary by N. H. Jasper, USA

676. Robson, J. D., Effects of non-linearity on the resonant frequency of a body (resting) on soil (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 344–349.

Paper approaches the problem of the vibrations of a machine foundation on soil by confining attention to resonant frequencies of a circular foundation resting on soil with a sinusoidally varying vertical force applied along its axis. The motion of such a foundation when resting on a semi-infinite linear elastic solid has already been adequately treated, but soil, even when sufficiently deep to be considered semi-infinite, cannot be expected to be linear. Some experimental work on the resonant frequencies of foundations on soil has been done previously, but there have been few attempts to explain observed phenomena; such attempts have been mainly based on the conception of an equivalent mass of soil which is assumed to move with the foundation.

From author's summary

677. Jones, J. P., The oscillations of a mass-spring system with multi-step friction damping, *J. Helicop. Assn.* **13**, 1, 57–69, Feb. 1959.

Author presents theoretical analysis for free and forced oscillations, comparing multistep friction dampers with viscous dampers. A criterion for the use of the equivalent viscous damper in ground resonance calculations is suggested. B. Smilg, USA

678. Gusev, N. F., The transformation of dry friction to viscous friction as an effect of vibration (in Russian), *Naucbno-tekbn. Inform., Moscow Lesotekbn. In-ta* no. 22, 59–64, 1956; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10798.

This is a faulty work, the author's purpose having been to add precision to the results obtained by A. A. Krasovskii [*Avtomatika i telemekhanika* **19**, no. 1, 1948]. When solving the problem of the constrained vibrations of a system with one step of freedom, the motion of which is described by the equation

$$m\ddot{x} + b\dot{x} + cx \pm F_\tau = F_0 \sin \omega t$$

(here $\pm F_\tau$ is the force of dry friction), author tries to derive a periodic solution by introducing into the first stage of the motion a new variable $y = x + F_{\tau/c}$ by presenting the general solution of the equation in the form of

$$y = c_1 e^{-\lambda_1 t} + c_2 e^{-\lambda_2 t} + D \sin(\omega t - \delta)$$

and by recording the conditions for the determination of the constants in the form of

$$[t = 0,\ y_0 = x_0 + F_\tau/c,\ \dot{y}_0 = 0$$

$$t = \frac{\pi}{\omega},\ y_{\pi/\omega} = -x_0 + F_\tau/c,\ \dot{y}_{\pi/\omega} = 0 \qquad [2]$$

Not noticing that δ is not an arbitrary constant but a known magnitude determinable from the equation

$$\tan \delta = \frac{b\omega}{c - m\omega^2}$$

author finds it from condition [2]. This deprives the paper and its results of all significance.

Note by the abstractor: The problem on the constrained vibrations of a system with one step of freedom in the presence of forces of dry and viscous friction was solved by Den Hartog [*Trans. ASME* 1931, 107–115].

G. Yu. Dzhanelidze
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

679. Sysoev, V. I., A pendulum damping device for vibrations of installations of a tower type (in Russian), Investigations on the dynamics of constructions, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1957, 61–82; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6975.

An experimental and theoretical investigation is conducted on a pendulum extinguisher, a model of which consists of a ball rolling in a groove fixed to the model of the tower. The damping of the vibrations of the model or of the actual tower is effected by the impact of the ball or of the pendulum on the model or the construction. The vibration recording of the model was carried out by means of a Geiger vibrograph fitted with a test rod; of the actual construction with a vibrograph as above with the use of the seismic principle. The theoretical investigation was centered in a scheme which showed a mass M set up on the top end (transposition x) of a vertical elastic rod L, subjected to impacts by a mathematical pendulum suspended near it (with mass m, length l, angular transposition φ); it is assumed that $M \gg m$, $L \gg l$. In the system the impacts take place with an impulse S at intervals of time T; in addition, a periodically exciting force P acts on the mass. The equations for the motion of the system have the form of

$$\ddot{x} + 2n\dot{x} + \lambda^2 x = \frac{P}{M} \sin(\theta t + \Psi) - \frac{S}{M} \sum_{R=0}^{\infty} \delta(t - RT)$$

$$\ddot{\varphi} + \omega^2 \varphi = -\frac{\dot{x}}{l} - \frac{S}{ml} \sum_{R=0}^{\infty} \delta(t - RT)$$

where $\delta(t - RT)$ is the impulse function; the rest of the terms have their generally accepted meanings. Author commences by examining the damping of the free vibrations, originating from the change in velocities of the striking together of the not fully elastic bodies, and connects up the solutions for the subsequent stages.

In this case the optimum conditions for damping are met with if

$$T_q = 0.5\,T_\omega + \tau,$$

where T_q is the period of the natural vibrations of the system, T_ω the period of the vibrations of the pendulum, τ the duration of the impact. The case of constrained vibrations is examined by the method of operational computation. The optimum amount of damping is obtained when $T_q = T$. It is shown that the effectiveness of the damping is dependent on the coefficient of regeneration. Results are given for experiments related to a number of models, a radio transmitting tower and a chimney stack, which confirm the expedient nature of the design for pendulum damping devices and which give some quantitative characteristics for the effects produced.

A. N. Obmorshev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

680. Singh, B. R., and Fush, V., Stick-slip sliding under forced vibration (in English), *J. Sci. Engng. Res., India* **2**, 2, 227–232, July 1958.

Paper studies the effect on stick-slip sliding of superimposed secondary uniform sinusoidal forces on the sliding element in a simple elastic system having viscous and coulomb damping and a constant-speed primary drive. It is found that the critical drive speed above which stick-slip motion will not occur is markedly effected by the frequency of the secondary forces. When the frequency of the latter is the fundamental resonance frequency the critical speed may increase by a factor as high as 13.3. High multiples (>10) of this resonance frequency yield substantially reduced and vanishing critical speeds for the system.

M. G. Scherberg, USA

681. Khodaverdian, V. M., The determination of the natural frequency of vibration of certain building materials by acoustic unison (in Armen.), *Izv. Akad. Nauk ArmSSR, Ser. Tekhn. Nauk* **10**, 1, 3–8, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2468.

The acoustic note of the vibration of the sample is compared by ear with the note produced by a generator. By turning the handle on the frequency scale of the generator, audible unison is obtained between the note emitted by the sample and that of the generator, after which the required natural frequency of vibration of the sample is read off the frequency scale on the generator.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

682. Denkhaus, H. G., Balancing problems encountered on a resonance vibrating conveyor, *So. African Mech. Engr.* **8**, 6, 183–188, Jan. 1959.

In this paper the problem of balancing natural frequency vibrating conveyors is dealt with. Conditions of balance are illustrated on a practical example. The possibilities of reducing vibrations in buildings caused by alternating forces transmitted from unbalanced conveyors are also briefly discussed.

From author's summary

683. Rubin, S., Design of accelerometers for transient measurements, *J. Appl. Mech.* **25**, 4, 509–514, Dec. 1958.

A number of design criteria on the acceptability of instruments for measuring transients are discussed. The paper suggests that the response spectrum of accelerometer output, as an undistorted version of the response spectrum of the transient, is the most valid criterion. Using an electric analog, different parameters of the response spectrum for single pulse of acceleration were plotted against T/τ (response period/pulse duration), for different values of damping ratio. Half-sine and triangular-input accelerations are considered. From results, it is concluded that for transient measurements (as in the case of measurements of periodic motions) a damping ratio of 0.6–0.7 is required; also the accelerometer period should be less than 0.4 of pulse duration for 5% accuracy. An attempt is made to extend conclusions to more complex transients.

Z. W. Dybczak, Canada

684. Singh, B. R., and Mohanti, H. B., Experimental investigations on stick-slip sliding, *Engineer, Lond.* **207**, 5384, 537–539, Apr. 1959.

It has been shown that the critical velocity of sliding of an elastic system driven with a fluctuating velocity under boundary friction is influenced by the frequency and the amplitude of the fluctuation. Again, the critical velocity of the elastic system is affected if the sliding mass is subjected to forced vibration. From results obtained on an electric analog computer, it appears that the critical velocity is considerably increased when the frequency of fluctuations or that of impressed force resonates with the natural frequency of the elastic system. At higher frequency ratios, the fluctuating drive does not appear to influence the critical velocity although in the case of forced vibration it was observed that the critical velocity was considerably decreased. It is thus concluded that where stick-slip effects are to be eliminated, resonant vibration should be avoided, while high-frequency forced vibration may be employed to advantage.

From authors' summary

Wave Motion and Impact in Solids

(See also Revs. 667, 722, 770, 993, 1008)

685. Pytel, A., and Davids, N., Further transient analysis of stress wave propagation in plates, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 358–381.

The effect of suddenly applied force gives rise to jump discontinuities in the displacement time relation, showing that a rapidly rising pulse causes a narrow zone of high stress at the front of the pulse.

Waves caused by the termination of the rectangular pulse cause reversed stresses of magnitude comparable to those produced by loading waves. This stress reversal is an important cause of the initiation of tensile cracks when the medium has yield strengths larger in compression than in tension.

For a unit step pulse, the displacements due to incident and reflected waves are in the same direction. Axial stresses approach asymptotically to the classical static solution for a unit load on a semi-infinite medium. The shape of plotted stress-time curves indicates that a part of the curves can be approximated by a family of parabolas. Though the forcing function is assumed concentrated at the origin, the elements near the origin which are subjected to elastic deformation may act as source points for additional elastic waves which arrive at a point later than the waves emitted directly by the load.

D. N. Mitra, India

686. Hsieh, D. Y., and Kolsky, H., An experimental study of pulse propagation in elastic cylinders, *Proc. Phys. Soc. Lond.* **71**, 608–612, 1958.

The response at one end of a bar was found after an explosive charge was detonated at the other. The observation was compared with the prediction of the Pochhammer theory (on the basis of phase velocity) using numerical Fourier synthesis. As might be expected from the form of the initial conditions, only the fundamental mode was found to be relevant under these conditions.

R. E. D. Bishop, England

687. Dass, B. N., Banerjee, S. K., and Bucknall, E. H., Effect of cyclic stress on mechanical properties of steels (in English), *J. Sci. Engng. Res., India* **1**, 1, 13–28, Jan. 1957.

Studies have been made of the effect of cyclic stress in flexure on static mechanical properties of three types of structural steel. The effects of over-stress (stress-cycle beyond fatigue limit) with different values of the ratio (applied cycles/cycles to fracture) have been determined in relation to the general nature of the true-stress/true-strain curve and the conventional mechanical properties by subsequent tensile tests. A small degree of work-hardening was noticed in two steels tested, but no appreciable change was detected in a third, softer steel. Such changes as occurred appeared to reach their maximum after a relatively small number of cycles and then the properties remain almost unchanged. This was true whether the cycles were of under-stress or over-stress. No evidence of crack formation was generally revealed in the tensile tests even when the number of fatigue cycles was as high as 75% of the anticipated number of cycles to fracture.

The results have been discussed in relation to the theory of the mechanism of fatigue failure. They indicate little chance of mechanical tests revealing impending fatigue failure in engineering components. From author's summary

688. Davids, N., Stress waves of penetration in plates, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 35–48.

An impact concentrated at a point of the surface of a plate may lead to "scabbing" effects—i.e. processes in which flat disk-like pieces fly off the specimen—on the other side of the plate. This effect may be analyzed theoretically by considering elastic stress waves excited at a point source on the surface of the plate. Waves penetrating through the plate the wavelength of which is of the order of the thickness of the plate are particularly important, so that the mathematical treatment is rather complicated. Author solves the boundary-value problem in question and evaluates the results using methods of the theory of functions of complex variables. As a special example the stress distribution for a certain aluminum plate is calculated numerically, showing the present maximum of tension. F. Engelmann, Germany

689. Herrmann, G., On the dynamic behavior of shells (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 293–299.

The purpose of this communication is to compare quantitatively the results of problem solved on the basis of author's three-dimensional theory of elasticity with those obtained from two approximate shell theories, namely the "thin-shell theory" and the "thick-shell theory."

The range of applicability of these shell theories is established. Two types of axially symmetric motions, the "breathing" and "pinching" modes, are taken in account, and the limiting geometrical cases of flat plate and solid cylindrical rod vibrations are included. J. S. Naleszkiewicz, Poland

690. von der Poel, C., and Kruizinga, J. H., Rates of propagation of transverse vibrations of an elastic plate on subsoil (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 364–374.

Experimentally observed wavelengths at various frequencies of a concrete plate on a clay subsoil were compared with results calculated by two theories: (1) Poisson-Kirchhoff plate on Winkler foundation, neglecting inertia effects in foundation; (2) Poisson-Kirchhoff plate on elastic solid foundation (smooth interface). Agreement between experiment and (1) was good except at low frequency (10 cps). Observing that experimental wave velocities lie between velocities of propagation of waves of distortion and dilatation, authors obtain solution of equations of motion of system (2) neglecting waves of distortion. This lends to equivalent subgrade modulus expressed in terms of Lâmé constants and frequency. Good agreement is then obtained for all frequencies for which the above inequality for wave velocity is satisfied.
K. S. Pister, USA

691. Tchen, C.-M., Dispersion of surface waves between viscoelastic media under magnetic field (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 127–136.

Author presents a study of waves at the interface of two semi-infinite viscoelastic media of different properties under the influence of a magnetic field. The basic equation (governing waves in a viscoelastic medium under a magnetic field) in the author's problem is written by employing the governing equations of magnetohydrodynamics for such a medium. A two-dimensional solution for the rotational velocity is considered in the form of infinite sinusoidal wave trains with amplitude a function of the variable normal to propagation direction. Substitution of this solution in the governing equation produces an ordinary differential equation for the amplitude function where the coefficients involve the wave number, material properties and magnetic field components. Approximations are then made to this equation based on interest in longer waves and related neglect of the conductive field. Application is then made to the case of two semi-infinite media. Author finds that both viscosity and the transverse magnetic field have large stabilizing effects on surface waves.
J. Miklowitz, USA

692. Plass, H. J., Jr., and Wang, N.-M., Longitudinal plastic waves in long rods of strain-rate dependent material, Proc. Fourth Midwest. Conf. Solid. Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 331–348.

Method of characteristics is used to solve the basic equations governing the propagation of stress, strain and particle velocity in a long rod subjected to a particle velocity step impact, large enough to produce plastic strains. For pearlitic steel and new rolled copper, the values of stress, strain and particle velocity are obtained for a number of points in the x-t plane on assumption of a linear form and also exponential form of the strain-rate function. The difference shows more rapid rate of decay of the stress and a more pronounced peak of permanent strain near the impact end in the expontential law than in the linear law.
D. N. Mitra, India

693. Yonezawa, H., On plastic deformations of beams due to impulsive load (continued report) (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **61,** 10–17, Mar. 1959.

In the author's previous paper [AMR **12** (1959), Rev. 3854], plastic deformations of cantilever beams are discussed under the assumption of "plastic-rigid" body, and the characteristics of unsymmetrical deformations are obtained.

Here the plastic deformations of the beams with one end built-in and the other simply supported under the blast-type load which is uniformly distributed or concentrated are analyzed theoretically. As a result of analysis, it is obvious that the deformations are divided into two classes for the distributed load and into five classes for the concentrated load, and the permanent deflections of each class are obtained. From author's summary
Courtesy, Editorial Committee of the Japan Society of Civil Engineers

694. Gwinn, J. T., Jr., For rough handling—these shock tests, *Prod. Engng.* **30,** 19, 74–77, May 1959.

Two rather simple methods of test-dropping the product are winning popularity. Author describes how they work—with curves, equations, and two sample problems from industry.
From author's summary

695. Pigulevskii, E. D., The sensitivity and resolution of acoustic-optical image conversion at a liquid surface, *Soviet Phys.-Acoustics* **4,** 4, 359–365, May 1959. (Translation of *Akust. Zh.* **4,** 4, 348–354, Oct.–Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The mechanism of a light image corresponding to the relief image at the surface of the liquid is explained. The effects due to surface tension and gravity are explained on the basis of the solution of the static relief equation.

Application of the diffraction theory of image formation to the case of elastic waves is examined. The theoretical conclusions are supported by experimental data.

From author's summary by A. Petroff, USA

Soil Mechanics: Fundamental

(See also Rev. 690)

696. Stepanov, A. P., On the destruction of frozen ground with the aid of impact loading (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 86–90, Apr. 1958.

Field tests were made on clayey silty soil by metal rammers. The drop height varied from 0.5 to 8 ms and the fall work from 135 to 4400 kgms. The specific destruction work has been determined in function of the form, the dimensions, the cutting (α) and the weight of the rammer, of the drop height (H), of the distance (l) of the destruction points from the boundary of the intact frozen zone, of the driving direction (β) as well as of the temperature, of the moisture and of the depth of the frozen ground. To better find out the influence of the temperature, of the moisture and of the kind of the soil, additional tests in freezing rooms were carried out.

The results show that for a given soil there are optimal values of α, H, l and β to which correspond the smallest specific destruction work and its greatest effectiveness. Generally, small heights H (around 2 ms), the inclination β around 85° against the intact ground and the distance l equal to, or somewhat bigger than, the width of the rammer are most favorable. The specific destruction work is the greatest at full saturation of soil and increases with the percentage of clay particles. Down to freezing depths of 0.70 m, frontal progression and chessboard layout of destruction points are favorable. The effectiveness increases considerably (up to 300%) if a net of initial cracks only is created by driving, and the blocks of frozen soil between the cracks are removed with a stripping device.

L. Suklje, Yugoslavia

697. Kosterin, E. V., Method for determining shear resistance in clay soils (in Russian), *Gidrotekhn. Str-vo* no. 7, 37–41, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4614.

The influence of the stressed and deformed condition on the resistance to shear of clay soils is demonstrated by means of experimental and theoretical investigations. It is noted that with small normal loads the actual surface of the cutting is smaller than the full area of the sample in the experiments. The divergence increases with decrease of the normal load. The actual shear resistance of clay soils when tested for stability by the old method is lower than it should be because of miscalculation of the slope of the cutting surface and of the concentration of the tangential stresses. The qualitative evaluation of the concentration of tangential stresses in cutting clay soils was carried out on the basis of Bingham's equation for uniform shear

$$\tau = \tau_1 + \eta(u/h)$$

where τ_1 is the shear stress limit, determined experimentally; η is the coefficient of viscosity, u the deflection (change of position) velocity, h the height of the shear zone. It was shown that at large pressures the concentration of stresses and the slope of the surface of the cutting, obtained in consequence of the constructional peculiarities of the cutting appliances, do not affect the experimental results.

I. V. Fedorov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

698. Ricard, S., Sourisse, S., Nougaro, J., Rouviere, R., Sablayrolles, C., Feger, J., Labouysse, M., and Thomas, A., Review of works on clay mixtures (Presented by the commission "Solutions") (in Russian), 4th International Petroleum Congress, **3,** Moscow, Gostoptekhizdat, 1957, 27–43; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3095.

1. Investigation of clay mixtures at high temperatures and high pressures (authors; as in the title). It was established by experiment that at a temperature of 250° and a pressure of 1000 kg/cm² the filtrate volume of clay solutions is at first proportional to the root of the square from the time of filtration and then increases sharply. At high temperatures the organic colloids disintegrate. Schematic designs of a filterpress, of a rotating viscosimeter of high pressure and of a circulation device are presented. 2. A new method of quantitative evaluation (technical engineering and technical-economic indicators) of colloid products, applicable to the technology for the preparation of clayey solutions (Ricard, Sourisse). On the basis of experiments, the concentration of clay and organic additions in clay solutions were expressed through the viscosity or water extraction; the exclusion of concentration from these relations gives the linkage between the viscosity and the water extraction. 3. Devices enabling continuous measurements to be made of the rheological properties of clay solutions (Nougaro, Ricard, Rouviere, Sablayrolles). A description is given of the field apparatus designed for the continuous measurement of the structural viscosity and shear stress of clay solutions. The action of the apparatus is based on the determination of the resistance to the flow of the solution through a pipe conduit, which is recorded by a galvanometer attached to a mercury manometer. For laboratory measurements of the given parameters a device is proposed, of a rotary type, with which the resistance to the turning of the rotor is measured also by electrical means. 4. Problem of drilling in honeycombed (porous) rock strata (Feger, Labouysse). A brief description is furnished of the methods used (tamponage, etc.) when drilling wells through rock strata containing cracks. 5. Investigation and method of application of new reagents for clay solutions (Thomas). The use of starch, Fucus sea-weed and humic acids in preparing clay solutions is described.

A. I. Golubev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

699. Tan, T.-k., Structure mechanics of clays (in English), *Scientia Sinica* **8,** 1, 83–97, Jan. 1959.

In order to study the rheological properties of clays a series of tests have been made with the help of torsion plastometers. In support of the test results obtained further experiments have been performed, showing that the internal stresses decrease with the time, when a clay sample is subjected to a constant deformation. A tentative analysis of the structure mechanics of clays is presented, based on the last concepts concerning the nature of the clay particle. The writer is inclined to believe that bound water plays only a secondary role as compared with the effects of the bonding forces between mutually connected plate-shape clay particles. It is shown that the structure mechanics of clays can be quite well based on the concept that the clay particles should form a network.

From author's summary

700. van't Woudt, B. D., Particle coatings affecting the wettability of soils, *J. Geophys. Res.* **64,** 2, 263–268, Feb. 1959.

The fundamental principles underlying the process of wetting show that a reduction in the surface tension of a solid substance

to be wetted reduces the wettability. Conversely, a reduction in the surface tension of the applied liquid increases the wettability. The wetting of a soil which exhibits water-repellency in an air-dry state can sometimes be achieved by leaving water in contact with this soil. There is some evidence that this wetting is achieved by an interaction of the solid and the liquid phase, leading to a reduction in the surface tension of the liquid. The phenomenon of advancing and receding angle of contact had led to an hypothesis that the angle of contact changes as the soil wets up or dries out. Some evidence is presented which does not support such an assumption, as the angle of contact seems fixed at a moisture content just above air-dry. There is some evidence that under certain conditions an improvement in the base status of the soil may lead to improved wettability. Particle coatings by hydrophobic films are in some cases responsible for the observed water-repellency. There is some evidence that this film is strongly adsorbed. No quantitative relationship could be detected between the characteristics of substances extracted by chloroform from a problem soil and the degree of unwettability of such a soil.

From author's summary

701. Thames, J. L., Measuring soil moisture over large areas with single installations of moisture units, *J. Geophys. Res.* **64,** 2, 257–262, Feb. 1959.

It seems possible that, with proper calibration, single installations of electrical soil-moisture units can be used to estimate moisture contents of outlying sites receiving similar amounts of rain but differing in vegetation and soils. In tests with data from northern Wisconsin and west-central Mississippi, predicted moisture contents agreed closely with those obtained by on-site measurements. Results were most accurate at seasons when the soils remained near the wilting point or near field capacity and were least accurate during periods of recharge.

From author's summary

702. Stroganov, A. S., A method of predicting the ultimate settling of the foundations of structures (in Russian), *Trudĭ Mosk. Energ. In-ta* no. 19, 240–272, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2186.

A critical examination of the calculations for the settling of foundations, made from the results of soil tests in compression instruments; such an analysis practically always gives a settling value many times the observed magnitude. The advantages are detailed of instruments working with multilateral compression (crushing gages), and the author's test installation of this type is described. The following are suggested as the fundamental relationships for sandy foundation soils: (1) $\theta_k = F_1(\sigma)$, where θ_k = bulk modulus in compression, σ mean compressive stress; (2) $T/\sigma = F_2(\Gamma)$, where T = intensity of tangential (i.e. shear) stress and Γ intensity of deformation in shear; (3) $\theta_s = F_3(T/\sigma)$, where θ_s = bulk modulus in swelling, the total volumetric deformation being $\theta = \theta_k + \theta_s$. Experimental curves are given for all three relationships. In calculating settling, it is suggested to determine the deformation characteristics from values of σ and T calculated for different points in depth of the foundation. These values are calculated by the stress formulas for a homogeneous, elastic semispace, in which, for simplicity, Poisson's ratio is assigned a formal value of 0.5. A table and a curve are given for determining the stresses. The values of σ and T must be determined for the initial stress condition (σ' and T'), in which external loading is absent, and the final stress condition (σ'' and T''), in which the load is applied, the stress due to the weight of the soil itself being assumed to follow a hydrostatic law. Assuming linearity of the relationships between stresses and displacements, author considers it possible to determine the shear modulus G, and the bulk modulus in compression K, by the following expressions:

$$G = \frac{T'' - T'}{\Gamma'' - \Gamma'}; \quad K = \frac{\sigma'' - \sigma'}{\theta'' - \theta'}$$

in which the values of Γ', Γ'', θ' and θ'' are determined from the above-mentioned experimental curves. The deformation modulus and the Poisson ratio are determined from these values of G and K. The actual calculation of the foundations is conducted by the usual formulas of the theory of elasticity for vertical displacements at an angle of a uniformly loaded, rectangular slab, situated on the surface of the semispace. The method of consecutive summation of the compression of the individual strata of the soil, the characteristics whereof have been determined by the above-mentioned method, is used. A series of auxiliary tables and curves is presented for the calculation of these values, using the method of angular points.

M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Soil Mechanics: Applied

703. Gray, H., Field vane shear tests of sensitive cohesive soils, *Trans. Amer. Soc. Civ. Engrs.* **122,** 844–863, 1957.

Compared to field vane tests to depths of 100 feet, shear strengths were less for vane tests on "undisturbed" tube samples. Shear strengths from unconfined compression tests on extruded samples were still smaller. Reduction in strength is attributed to unavoidable disturbance in sampling and trimming. Discussions suggest reduction in strength is due to reduction in confining pressure. (Rate of vane rotation should be very slow. In Formulas 4, one end resistance only is included.)

E. S. Barber, USA

704. Antonevich, P. B., Reciprocal influence of additional loading on the sagging of parallelly disposed ribbon foundations (in Russian), *Sb. Nauchn. t. Tomskii Inzh.-Stroit. In-ta* **2,** 31–48, 1957; *Ref. Zh. Mekh.* no. 6, 1958; Rev. 6944.

Use is made of the membrane model of an elastic foundation developed by M. M. Filonenko-Borodich, which possesses the properties of a heavy liquid with surface tension [see *Izv. Tomskogo Politekhn. In-ta*, **76,** 181–187, 1954]. An investigation was made, in conditions of a plane problem, of the case of mutual influence on the settling of parallelly disposed infinitely long rigid strips with regular and irregular sagging; an examination was also made of the influence exercised on the sagging of closely disposed foundations by overloading in the form of concentrated forces, distributed over a certain part with (1) constant intensivity and (2) with an intensivity varying in accordance with the linear principle. Examples of the calculations are given.

I. V. Kiseleva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

705. Shakhunyants, G. M., Calculation for the stability of the foundations of an installation on the hypotheses of plane and round-cylindrical surface changes of position (in Russian), *Trudĭ Mosk. In-ta Inzh. Zh.-d. Transp.* no. 80/1, 319–339, 1955; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4590.

A method of computation is explained for the calculation of the stability of the foundations of installations, taking into account the forces of friction and cohesion, on the assumption that the surface of slip is round-cylindrical. The solutions are given in both the analytical and the graph-analytical forms. The critical round-cylindrical surface of slip, by author's assumption, should more

nearly approach the surface of change of position, consisting of the ascertained critical planes. Following this, author examines three variants, and calculation formulas are given for the determination of the radius and position of the center of the round-cylindrical surface of slip at which the stability coefficient would differ only slightly from its smallest value. (1) The round-cylindrical surface passes through rib A on the extreme edge of the foundations and touches the surfaces of transposition of the prism of collapse and resistance. (2) The round-cylindrical surface passes through the same rib A of the foundation and through line B of the intersection of the surface of transposition of the prism of resistance with the visible surface of the foundation with the condition that the area of the cut-off segment shall be equal to sum of the areas of the prism of pressure, of the embedded part of the foundation, the prisms of collapse and resistance. (3) The round-cylindrical surface passes through A and B, as in the previous case, and, in addition, through apex D of the prism of collapse and resistance. The stability coefficient K of the foundation of the installation, when transposed along the round-cylindrical surface, is determined from the relation

$$K = \frac{R\,[cR\Psi + F + F_D] + \frac{1}{2}Gg + M_n}{M_t + \frac{1}{2}Gg + M'_n + M_w}$$

All the moments entering into this expression are determined by the author in terms of the function of the coordinates of the center of the circle x_0, y_0 and its radius R.

A. I. Govyadinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

706. Demin, A. M., Use of the theory of limiting equilibrium for calculating the stabilities of rock dumps (in Russian), *Ugol'* no. 9, 21–23, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8034.

An engineering method of calculating the stabilities of dumps made on level ground is set out. The foundations of the dumps are assumed to be stable, the shape of the dump slope to be rectilinear. The following proposition is the basis of the proposed method of calculation. A rectilinear slope will be stable if its height H does not exceed the ordinate x of a point N on the equal stability slope, at which direction of the tangent to the outline of the slope makes an angle α with the horizontal equal to the angle of the slope, plus the height H_{90} of the elastic layer:

$$H \leq x + H_{90}$$

Here

$$H_{90} = \frac{k}{\lambda}\,\frac{2\cos\rho}{1-\sin\rho}$$

where k is the adhesion and γ the weight by volume of the rock. Using the tables given by P. S. Mukhin and A. I. Stagovich ["The plotting of the limiting shapes of equal stability slopes," Moscow, Iz-vo, Akad. Nauk SSSR, 1954, 24 str], the author plots graphs for the family of α = const. curves. These curves express the relationship which is required with ρ, the angle of internal friction for the limiting weight of a stable dump with a rectilinear shape of slope, at a given angle α to the horizontal.

A. I. Govyadinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

707. Archashnikov, V. P., Calculation for the optimum dimensions for the supporting rock columns between the galleries of mines (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Matem. i. Mekhan.* no. 5/93, 3–28, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4626.

Based on the theory of the limit of equilibrium of a friable medium, a solution is given for the problem of the determination of stresses in pillars of rectangular section. The calculation scheme relies on the assumption that the compression of the rock of the pillar is located between two rough plates (the roof and the foundation of the pillar) and that the stresses acting between the plates and the rectangle are bound by the equality

$$|\tau_{nt}| = \sigma_n \operatorname{tg}\psi$$

(σ_n, τ_{nt} are the normal and the tangential stresses, while ψ is the angle of friction between the rock of the pillar and the rocks of the roof and the sole). The problem is solved for the cases where the ratio of the width of the rectangle to its height is sufficiently large and also where this ratio has a commensurate value. A numerical example for the calculation of the stresses in the pillar is given.

I. V. Fedorov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

708. Strelaev, M. I., Problem of the determination of bending parameters of an infinitely long pipe suspended at one point (in Russian), *Trudi Kuibyshevsk. Inzh.-Stroit. In-ta* no. 4, 111–123, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1168.

Author considers problem of deformation of an infinitely long pipe (or bar) which lies on a rigid foundation and is uplifted at some point by a concentrated force. A similar problem arises in the laying of long pipelines.

Author in solving this problem proceeds from an erroneous assumption that the force applied at the suspension point is equal to the total weight of the uplifted part of the pipe. In fact, part of the weight is shared by the foundation in the form of concentrated forces at the ends of the uplifted pipe section. In the particular case, for example, if the pipe lies on a plane the force at the suspension point consists of 2/3 of the total weight of the uplifted section. The under-root term in Eq. [7] would be consequently three times larger than presented by the author.

S. V. Boyarshinov

Courtesy Referatinvyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Processing of Metals and Other Materials

(See also Revs. 613, 730)

709. Kruger, P., Measurement and control of surface temperature of rotating rolls (in German), *ZVDI* **101**, 9, 343–346, Mar. 1959.

If the surface temperature of rotating rolls is measured with stationary thermocouples, which are pressed against the surface, the resulting frictional heat might falsify the reading. Therefore it is better to use thermometers mounted a short distance above the roll surface. The heat passes from the surface to be measured through the layer of air to the thermometer, through thermal conduction, convection and radiation. Errors in reading through heat escaping to the surrounding area can be compensated with comparative ease. Such sensitive elements serve not only for recording temperatures but can also be employed for controlling the temperature of the rolls.

From author's summary

710. Mathea, A., Nomograms for the determination of rolling efforts, based on the equation of S. Ekelund (in German), *Stahl u. Eisen* **78**, 20, 1383–1389, Oct. 1958.

711. Peckner, D., and Ginsburg, H., Evaluating tool life, *Tool Engr.* **42**, 3, 75–79, Mar. 1959.

Statistical methods when applied to tool wear testing can predict performance quickly. The authors describe a useful technique

and illustrate the principles with a report of a study performed on form cutters used to machine slots.

From authors' summary

712. Aida, T., and Okamoto, T., Fundamental research on coal cutting, *Bull. JSME* **2,** 5, 51–58, Feb. 1959.

To determine the workability of coal face underground, authors have carried out fundamental experiments on coal cutting in the laboratory. Authors describe the relations between the cutting resistance and cutting conditions, i.e., depth of cut, bit angle, cutting speed, bit wear, and physical properties of coal.

From these experimental results, authors learn that the magnitude of cutting resistance of coal cutter or coal planer at the coal face underground could be generally anticipated.

From authors' summary

713. Okushima, K., and Minato, K., On the behavior of chip in steel cutting, *Bull. JSME* **2,** 5, 58–64, Feb. 1959.

Paper describes the behavior of chip in steel cutting for the purpose of controlling the shape of chip. The first part describes the angle of flowing-out of chip and, since its values calculated by the theoretical equations are in accord with the measured values for various cutting conditions and tool designs, authors have drawn up nomographs for the flowing-out angle of chip on the basis of the theoretical equations. The latter part describes the chip classification and the effect of cutting conditions on the shape of chip.

From authors' summary

714. Dall, A. H., and Fivoira, E. J., Electro-hydraulic applications to machine tools, ASME-Design Engng. Conf., Chicago, Ill., Apr. 1958. Pap. 58-MD-5, 15 pp.

715. Sedokov, L. M., The kinematic analysis of the continuous chip formation process (in Russian), *Izv. Tomskovo Politekhn. In-ta* **85,** 149–168, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8014.

The analysis is made on the basis of the time-Zvorykin approximate chip formation diagram, i.e. on the assumption that cutting is a plastic shear deformation process, owing to which all the displacements must occur by shears in the "shear plane." The relative location in the chip of any particle in the layer removed is determined, and analytical expressions are obtained for the geometrical parameters of cutting. Remarks are made as to grain shape before and after deformation. The author notes that in actual fact the shears occur not only in the shear plane but also in "a more or less large plastic deformation zone"; however, the article contains no attempt to assess this circumstance quantitatively.

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

716. Rozenberg, A. M., and Nassonov, K. A., The factors affecting the process of deformation during cutting (in Russian), *Izv. Tomskovo Politekhn. In-ta* **85,** 118–131, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8015.

The factors affecting the degree of deformation of chips during their formation are discussed. Authors disagree with other research workers. On the basis of experimental results the authors produce a number of considerations as evidence of the presence of a relationship of the one sign between the degree of plastic deformation of the cut layer and the coefficients of friction of the chip along the leading edge of the cutting tool.

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

717. Yatsyuk, A. I., Influence of power cutting on the fatigue stability of steel (in Russian), *Naucbn. Zap. In-ta, Mashinoved. i Avtomatiki, Akad. Nauk SSSR* **6,** 33–41, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7207.

It was demonstrated experimentally that power-cutting lowers the endurance of steel components when they are working in air. A still greater drop is observed when such components are cyclically immersed in water. It was shown that roller milling of the components which had been power-cut significantly increases the endurance in the air and more especially in a corrosive medium.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

718. Rozenberg, A. M., and Rozenberg, Yu. A., The influence of rate of deformation, and of temperature, on the stresses when cutting brittle metal (in Russian), *Izv. Tomskovo Politekhn. In-ta* **75,** 47–55, 1954; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8204.

Tests have proved that the tangential stresses in the shear plane calculated for the cutting of cast iron depend on the hardness of the iron and scarcely at all on the cutting rate. The temperature in the shear zone depends on the amount of heat liberated per unit volume of metal; it is associated with the angle of shear, and varies with relation to the hardness of the iron. The influence of temperature on hardness during cutting is small; temperature can therefore be expected only to have a small effect on the stress.

P. S. Pautyinskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

719. Teplitsky, E. I., The interaction between stamp dies and foundations (in Russian), Avtoref. Diss. kand, Tekhn. Nauk, Mosk. Inzh.-Stroit. In-ta, Moscow, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2065.

720. Kashcheev, V. N., Comparison of the abrasive properties of grains of minerals by the method of mutual grinding, *Soviet Phys.-Tech. Phys.* **2,** 5, 1001–1005, Feb. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 1100–1105, May 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)

721. Finnie, I., Tube diameter and thickness gauge for high temperatures, *Rev. Sci. Instrum.* **29,** 11, p. 1054 (Notes), Nov. 1958.

Fracture (Including Fatigue)

(See also Revs. 614, 687, 718, 751, 791)

Book—722. Conference on fracture (International seminar on atomic mechanisms of fracture, Swampscott, Mass., Apr. 12–14, 1959, Washington, D. C., National Academy of Sciences, 1959, 659 pp. (Paperbound)

Twenty-five papers on theoretical and experimental aspects of fracture in metals, polymers, glasses, ceramics and ionic crystals are included. Some points on which there was fairly general agreement were: (1) Transcrystalline brittle cracks result from vacancies formed by intersecting dislocation pile-ups. (2) The propagation of brittle cracks is often discontinuous and is dependent on both the size of the initial flaw or crack and on the availability of sufficient energy to form the new free surface. (3) Both fatigue and ductile fractures are preceded by a concentrated local deformation of large magnitude in narrow slip bands.

Several papers of a descriptive nature provide information on fractures produced by ultrasonic vibrations, high-speed photography of fractures, fine structure of fracture surfaces (by electron microscopy), and microstructural features of fatigue.

J. A. Bennett, USA

723. Volarovich, M. P., and Parkhomenko, E. I., Investigation of fracture due to torsion of thin rock samples during pressure on one side (in Russian), *Izv. Akad. Nauk SSSR Ser. Geofiz.* no. 2, 190–199, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5874.

Tests are described of the disruption, of the explosive type, of different rocks (granite, diabase, basalt, basalt glass, gabbro, syenite, quartzite, marble and dolomite) during torsion in conditions of pressure applied to one side. All the rocks showed signs of disruption of the explosive type at one or another sufficiently large one-sided pressure. Some of the rocks (granite, basalt, quartzite, etc.) become deformed with crackling and crunching, others (dolomite and marble) deform smoothly. The last two, because of lower limits of stability in regard to torsion, disrupt explosively at pressures which exceed the minimum pressure of disruption for such rocks as granite, basalt, etc., by several times. Artificial basalt glass and natural basalt behave in a different way in such tests, which can be explained by the different nature of their structure. K. S. Zavriev

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

724. Ion Mikhai, P., Stability against crack-formation and the flexural strength of deflecting ferroconcrete structures with the usual and with prestressed reinforcement (in Russian), Khar'kovsk Regional Scientific Technical Conference on Ferro-Concrete Structures, Dec. 1954, Khar'kov, 1956, 61–73; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3442.

An investigation was carried out of the features observable at the moment of crack formation and the loss of flexural strength in deflecting "armo-concrete" (lightly reinforced) components. An analysis is made of the effect of the application of prestressing and the expediency of using materials of high stability. The bond between the stresses and deformations during deflection is accepted on the basis of the concept of the time-curve of deflection, taking into account the deformation of the aftereffect (creep). A deduction is made on the subject of the marked influence of the concrete of the tensioned zone on the flexural strength, which, in turn, is affected strongly by employment of a higher grade of concrete. Prestressing of "armo-concrete" structures increases the stability against crack formation. I. I. Ulitskii

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

725. Narzullaev, B. N., and Kolmykova, L. G., The physical theory of strength of solid bodies (A review of modern concepts) (in Russian), Akad. Nauk TadzhSSR, **54**, 103–114, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5802.

Article is in the nature of a review. An investigation is made of the generally accepted theory of brittle fracture (Griffith's theory) and it is observed that stress is not the only factor involved in mechanical fracture. The effects of time on toughness, which previously were looked upon as secondary phenomena, have now acquired the principal interest and serve as the main subject of inquiry in the author's studies. An explanation is given for the time-dependence factor of toughness according to Murgatroyd and Orovan. It is noted that the time-dependent character of toughness leads inevitably to a re-examination of the established concepts of the limit of toughness as characteristics not dependent on the duration of the stress action. L. S. Brynkhanova

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

726. Freudenthal, A. M., and Heller, R. A., On stress interaction in fatigue and a cumulative damage rule, *J. Aero/Space Sci.* **26**, 7, 431–442, July 1959.

Authors propose a cumulative damage rule to predict fatigue life of parts subject to a stress cycle of variable amplitude. In contrast to the Miner-Palmgren hypothesis this one has been given a nonlinear form to make it possible to include stress-interaction effects. Predictions from this rule are compared with experimental results from 2024 aluminum alloy and 4340 aircraft steel. Fatigue tests were performed on smooth specimens, using a rotating bending fatigue machine with six load levels, controlled by a punched tape. Load spectrum was composed to simulate a gust and maneuver load sequence of an aircraft. Test results support the proposed cumulative damage rule. A. Isaksson, Sweden

727. Welter, G., and Choquet, A., Internal-stress distribution of single spot welds in relation to their fatigue life, *Welding J. Res. Suppl.* **38**, 4, 145-s–157-s, Apr. 1959.

The responsibility of residual tensile stresses in the spotwelds for low fatigue strength of spotwelded assemblies has been confirmed. Residual tensile stresses in the plane of the sheet of between 32,000 to 35,000 psi have been found in spotwelds in spotwelded 0.064 in. thick, type 301, ½ hard stainless steel. Fatigue limit of such an "as received" spotweld was 300 lbs or 7% of the static tension pulling load. Annealing (stress relieving) increased fatigue limit to 600 lbs. The application of a dynamic load normal to the spotweld and producing normal (compressive) stresses around 200,000 psi changed tensile residual stresses into compressive stresses of the order of 35,000 psi. Such a treatment increased the fatigue limit to 1400 lbs, or 30% of the static tension pulling load. This represents the increase of 450% in relation to spotwelds "as received." The usual tensile-shear strength is not affected by such a treatment. All fatigue tests were of the pull-pull type and up to 10,000,000 cycles.

Reviewer's remark: This paper, although it does not contain any new discovery, is an important contribution to the understanding of causes of low fatigue strength of spotwelded structures and shows the potential means of increasing it.

J. Koziarski, USA

728. Anderson, W. J., and Carter, T. L., Effect of fiber orientation, temperature and dry powder lubricants on rolling contact fatigue, *ASLE Trans.* **2**, 1, 108–120, Apr. 1959.

Paper is a condensed rewrite of NACA TN 4163 and TN 4216 on Macks spin-rig tests of 8 ball materials, and 18-4-1 races machined from billet at various angles to direction of forging. Results are analyzed with respect to fiber orientation at the test surface. End grain shows 1/2 to 1/5 the life of parallel grain. Micrographs show failure with solid lubricant is hastened by stress raisers in the bands of pure rolling. Raising temperature (M-1 balls, sebacate lube) from 100 F to 250 F and 450 F reduces life. Reviewer comments that single-ball tests have proven notoriously inconsistent, especially when inadequate numbers of samples are run. Authors' dog-leg Weibull plots would presumably straighten out if enough tests were run.

For more data, charts, micrographs on the spin rig, see NACA TN's 3925, 3930, 3933, 4101, 4161, 4163, 4216, and NACA RM E57K12. E. A. Ryder, USA

729. Carter, T. L., Butler, R. H., Bear, H. R., and Anderson, W. J., Investigation of factors governing fatigue life with the rolling-contact fatigue spin rig, *ASLE Trans.* **1**, 1, 23–32, Apr. 1958.

A simple bench test for evaluating materials and lubricants under actual rolling-contact stresses is described. Stress-life relationships for mineral-oil lubricated SAE 52100 balls and AISI M-50 (MV-1) tool steel cylinders compared favorably with those obtained in full-scale bearings. Most failures originated in subsurface shear and closely resembled those obtained in bearings.

A study of the effect of fiber orientation on fatigue strength revealed that the polar (or end grain) area was weaker in fatigue than the nonpolar area. Structure changes were found in the highly stressed regions of both SAE 52100 and AISI M-1 tool steel. In-

clusions, structure change, and directionalism are believed to adversely affect fatigue life. From authors' summary

730. Takeuchi, S., and Homma, T., Effect of shot-peening on fatigue strength of metals, Part I: Effects on polished state; Part II: Effects on decarburized steels; Part III: Effect on steel with notch, *Sci. Rep. Res. Inst., Tohoku Univ., Japan* (A) **10,** 6, 426–434, Dec. 1958; **11,** 1, 48–55, Feb. 1959; **11,** 2, 94–101, Apr. 1959.

Rotating beam tests on Si-Mn steel 17S Al alloy and 4/6 brass indicated 3 to 13% increase in fatigue strength by shot-peening; little change was caused by repolishing to remove surface roughness after shot-peening. Annealing at high temperatures to soften the surface layer hardened by shot-peening lowered the fatigue limit. Decarburization reduced the fatigue limit of Si-Mn steel to 50% of that of a polished specimen; subsequently, shot-peening restored about half of this loss in fatigue strength. Shot-peening of rotating beam specimens of high-strength spring steel with a circumferential groove or a sharp V notch was effective in increasing the fatigue strength 33% and 73% respectively. Particularly interesting was the fact that the peening was especially effective in this case even though the shot did not reach the root of the notch (the shot being too large in diameter to fit into the sharp V groove). T. J. Dolan, USA

731. Stevens, G. H., and Boller, K. H., Effect of type of reinforcement on fatigue properties of plastic laminates, WADC TR 59-27, 51 pp., Sept. 1958.

Fatigue-strength values are presented for four epoxy and two phenolic laminates subjected to axial loading. The epoxy resin laminates were reinforced with 181-Volan A glass fabric and with plies of continuous, unwoven glass fibers. The phenolic resin laminates were reinforced with parallel or cross-laminated lay-ups of asbestos mat. S-N curves are presented, representing the fatigue data after the laminate had been cycled in the fatigue machine from about 1,000 to 10 million cycles with 0 mean stress at 900 cycles per minute. Fatigue tests were made at 73 F and 50% relative humidity and at 100 F and 100% relative humidity.

When laminates were loaded parallel to a principal fiber direction, an endurance limit was generally not reached even after 10 million cycles of loading. After 10 million cycles, the fatigue strength of the epoxy laminates varied from about 15 to 35% of the corresponding lowest value of tensile or compressive control strength, while that of the phenolic laminates was about 45 to 65% of the compressive control strength. The fatigue strength of all laminates at any number of cycles was usually about 10 to 30% less for wet specimens than for dry specimens, but a reduction up to 45% was indicated.

The presence of a small circular notch generally had only a small effect on the fatigue strength of the laminates, irrespective of the angle of loading or number of cycles. The difference in fatigue strength between notched and unnotched specimens was usually less than 10%.

Properties of epoxy laminates reinforced with continuous, unwoven glass fibers vary greatly with the orientation of the plies and direction of loading, both under static and repeated loading. In these and the other laminates evaluated, however, the fatigue strength values at 10 million cycles had a much smaller spread than did the static strength data.

From authors' summary

732. Kogaev, V. P., Methods of statistical handling of the results of fatigue tests (in Russian), *Zavod. Lab.* **23,** 5, 612–620, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7196.

Paper is a survey of methods used to obtain the functional relation between the stress, the number of cycles up to disruption and the probability of disruption of the test sample, fracturing at the given stress and number of cycles, or at a lesser number or a number equal to that given. V. S. Namestnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

733. Korchinskii, I. L., Taking account of the appearance of fatigue in building construction (in Russian), *Nauch. Soobshch. Tsentr. N.-i. In-ta Prom. Sooruzh.* no. 25, 72 pp. + illus., 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3382.

Practical recommendations are made for the calculations of building constructions, made from steel, ferroconcrete and timber, regarding the mutual action of static and cyclic loads, characterized by asymmetrical cycles. It is recommended to utilize the linear principles incorporated in the formulas

$$\alpha_{cp}\sigma_{cp} + \mu\alpha_a\sigma_a \leq |\sigma|, \qquad \sigma_{cp} + \sigma_a \leq |\sigma|$$

where σ_m and σ_a are the mean and amplitudinal values of the cycle's stresses, σ the permissible stress during the action of static loads, α_m and α_a the coefficients characterizing the properties of the materials, μ the coefficient characterizing the type of construction being computed for cyclic loading. Recommendations are made for the numerical values of the coefficients.

N. N. Davidenkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

734. Goltsev, D. I., Approximate evaluation of the endurance limits of structural materials (in Russian), Vopr. dinamiki i dinamicheskoy prochnosti, no. 3, Riga, Akad. Nauk LatvSSR, 1955, 65–73; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2405.

A method and equations are presented for evaluating the endurance limit from the data of tests on a limited number of samples. It is assumed that the responsible factor in the origination of fatigue cracks is the quantity of work $W - W_0 = \text{const}$, where W is the total energy absorbed by unit volume of the material, N load cycles, corresponding to the appearance of fatigue cracks; W_0 = maximum safe unit absorbed energy during the same N cycles of load variation. It is also postulated that the area of the hysteresis loop over a wide range of load cycle numbers N is independent of the numerical order of the load-change cycle; i.e. $(\Delta W - \Delta W_0) = \text{const}$. It is further assumed that the maximum stress should not exceed the yield point of the material.

B. F. Balashov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

735. Ivanov, V. V., and Kobrin, M. M., Increasing the fatigue strength of cylindrical and conical shafts through surface cold-hardening by roller burnishing (in Russian), Vopr. konstrukts. prochnosti stali, Moscow, Mashgiz, 1957, 40–66; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1232.

A method of surface cold-hardening by roller burnishing is suggested to increase the fatigue strength of pressed fittings. Examples are given of the treatment of a crankpin and a piston.

From authors' summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

736. Salokangas, J., Fatigue failures of the connecting rods of frame saws under corrosion (in Finnish), *Acta Polytech. Scandinavica* no. 251, 23 pp., (Mechanical Engineering Series no. 4), 1958.

The material of the connecting rod and the forces acting upon it at sawing are discussed. Calculation yields for the dynamic stress of the connecting rod the value ±4 kp/mm²; measurements with strain gages, the value ±5 kp/mm².

Fatigue under corrosion in general and the corrosive conditions in the saw mills in Finland are treated. Author arrives at the result that under the prevailing conditions an unprotected connecting rod will inevitably fail before long, caused principally by fatigue load under corrosion. Numerous examples and illustrations relating to corrosion and fatigue failures and to incipient failure are presented.

Failures are much more frequent in seaside than in inland saw mills. 135 connecting rods have been investigated with the aid of ultrasonics, with the result that 72 incipient failures of 1 to 6-mm depth were found. The failures prefer localisations closer to the ends of the connecting rod; this trend is consistent with the heavier corrosion of the ends due to their increased temperature, which is caused by bearing friction. In connecting rods with needle bearing no failures of the upper eye have occurred.

An investigation, carried out in laboratory conditions, of the progress of a fatigue failure in a connecting rod removed from service and with an established, lesser incipient fatigue failure is presented.

Information derived from the literature, relating to the protection of connecting rods against fatigue corrosion, is presented.

From author's summary

737. Borik, F., Chapman, R. D., and Jominy, W. E., The effect of per cent tempered martensite on endurance limit, *Trans. Amer. Soc. Metals* **50,** 242–254, 1958.

The effect of microstructure on the endurance limit of the following steels has been investigated: SAE 1340, 4042, 4340, 5140 and 80B40. Using different quenching media and by changing the cross section of the quenched bars, various amounts of martensite were produced by continuous cooling.

A relationship appears to exist between the amount of martensite obtained in the "as-quenched" condition and the endurance limit of low alloy steels. This correlation is based on steels with carbon content in the range of 0.39–0.45% and about the same tempered hardness (Rockwell C-36), but with different hardenabilities.

This relationship shows that the endurance limit drops with the presence of small percentages of nonmartensitic products. As the percentage of martensite decreases below 85%, the endurance limit is not as sensitive to microstructure.

The results indicate also that the endurance limits of the above steels as determined in tests with R. R. Moore machines were nearly the same for a given amount of martensite when tempered to a given hardness irrespective of their hardenability.

From authors' summary

738. Volkova, T. I., The relaxation process in conditions of repeated loading (in Russian), *Metallovedenie i Obrabotka Metallov* no. 7, 13–18, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7218.

Experimental data are furnished on the influence on the relaxation stresses of repeated loading with heating in between the loadings. For the repeated loading tests ring-shaped samples were used, made of industrial iron and of steels marks 20 and 40 at a temperature of 400°. It appeared that a preliminary prolonged loading for 3200 hours very strongly raises the relaxation stability at the second loading. At the third loading the relaxation process proceeds still more slowly, while the fourth and fifth loading show no practical differences from the third. When investigating the reaction of heating between the loadings on the relaxation stability of test samples made of steel mark 50 it was apparent that the intermediate heating of the unloaded samples before repeated loading decreases the effect of the raising of the relaxation stability connected with the repeated loading; the decrease becomes more marked as the difference between the heating temperature and the temperature at which the test is made increases.

G. M. Ivanova

Courtesy Referativnyi Zhumal, USSR
Translation, courtesy Ministry of Supply, England

739. Pridantsev, V. M., and Krylova, A. R., A method of determining the resistance to thermal shock of sheet steels and alloys, *Indust. Lab.* **24,** 2, 216–218, Mar. 1959. (Translation of *Zavod. Lab., SSSR* **24,** 2, 204–205, Feb. 1958 by Instrument Soc. Amer., Pittsburgh 22, Pa.)

Apparatus is described for thermally cycling a sheet specimen having an arbitrary size and configuration of holes and for measuring number of heating and cooling cycles required to produce first crack. This is a comparative test which does not yield basic material properties. Tests on austenitic chromium-nickel steel indicate that the logarithm of the cycles to first crack decreases with increasing temperature amplitude (range studied was 400 C and 1000 C). Cycles to thermal fatigue failure also decrease with increasing sheet thickness and decreasing grain size.

B. J. Lazan, USA

740. Kats, Sh. N., Creep and failure of tubes under internal pressure (in Russian), *Izv. Akad. Nauk. SSSR, Otd. Tekh. Nauk* no. 10, 86–89, Oct. 1957.

Author considers symmetric large deformation of thick-walled cylinders of incompressible material in presence of creep following Norton's law generalized to three-dimensional case by way of the time derivative of logarithmic strain. He proposes to calculate time period to creep rupture in a similar way as N. J. Hoff for a test piece in uniaxial tension [AMR **6** (1953), Rev. 2523], i.e. he calculates the time necessary to creep the tube down to zero wall thickness. He also computes an equivalent rupture time for tubes under internal pressure and makes favorable comparisons with experiments on stainless steel tubes.

F. K. G. Odqvist, Sweden

Experimental Stress Analysis

(See also Rev. 727)

Book—741. Foppl, L., and Monch, E., Practical photoelasticity [Praktische Spannungsoptik], 2nd ed., Berlin, Springer-Verlag, 1959, xi + 209 pp. DM 30.

By the first edition of this book, printed in 1950 [AMR **4** (1951), Rev. 3170], authors intended first of all to show engineers how to apply photoelasticity to the control or design of machine parts or structures. Thus it was not a general treatise on artificial birefringence, but merely a special book for practical purposes. However, to a certain degree, they have exceeded this goal because one can find in their book a summary of the enormous experience which was attained in photoelasticity over a great number of years in the laboratory of Professor L. Foppl in Munich.

In this second edition, very much enlarged compared to the first, the authors go even further. They not only take account of the recent improvements in the classical methods of photoelasticity but they have also extended the part where different special optical procedures are described by which the field of application has become expanded.

The second edition is therefore completely revised, taking account of the principal advances of the past ten years, especially those concerning the three-dimensional photoelasticity. Let us also point out that the book contains certain interesting considerations on photoelasticity.

We recommend this second edition very much, not only to scientists who work in this field but also to any engineer who has to do with the delicate problem of evident pedagogical purpose, and last but not least because of its illustrative pictures. Thus students of technical branches may also read it with interest.

Let us finally outline briefly the different chapters:

I. The experimental and theoretical foundations of photoelasticity: 1. Two-dimensional photoelasticity, 2. Three-dimensional photoelasticity, 3. Interpretation of the results.

II. Special methods in photoelasticity: 1. The reflexion polariscope, 2. Further methods for the complete determination of a two-dimensional state of stress, 3. Bending of plates, 4. Investigations on shells, 5. Special methods in three-dimensional photoelasticity, 6. Dynamical investigations, 7. Photoplasticity.

III. Practical applications of photoelasticity: 1. State of stress in cog wheels, 2. Stresses in foundations, 3. Hood of plexiglass under overpressure, 4. Branching of pipes under pressure, 5. Investigation of the ceiling containing tubes of suction in a block of the power station Jochenstein, 6. Screens against wind in a steel concrete skeleton construction, 7. Investigation of a state of stress in a dam, using a model of gelatin, 8. Examination of parts in steel concrete with armed models, 9. Verification of Saint-Venant's principle by photoelasticity, 10. Elastic states of stress in bodies containing plane slices.

H. Favre, Switzerland

742. Theocaris, P. S., Stress concentration produced in perforated strips under tension, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 129–136, 1958.

The stress distribution for a strip loaded in tension at a central hole through a close-fitting pin is determined photoelastically and with the aid of an electrical analogy. There is good agreement with the theoretical results already published by the same author.

A. F. C. Brown, England

743. Brock, J. S., The determination of effective stress and maximum shear stress by means of small cubes taken from photoelastic models, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 1–8, 1958.

This paper presents a method for determining the Hencky-von Mises effective (or uniaxial equivalent) stress in terms of directly measurable photoelastic quantities. The method consists of freezing the stress into a three-dimensional photoelastic model and cutting the model into small cubes. Then retardation and orientation angle measurements are made in the three coordinate directions of the cube and are used directly to determine the effective stress. The method may also be used to determine the directions of the principal stresses and the magnitude of maximum shear stress.

From author's summary by O. Halasz, Hungary

Book—744. Gubkin, S. I., Dobrovol'skii, S. I., and Boiko, B. E., Photoplasticity (in Russian), Minsk, Izd-vo. Akad. Nauk BSSR, 166 pp., illus., 1957, 7r 50k; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6256.

To start with, a very condensed account is given of the basic information available on the interference of polarized beams which have passed through the deformed model. Then an analysis is given of the properties of materials used in photoplasticity and the requirements presented by them. Apparatus is described, as also the techniques for preparation of the models and the procedure adopted in carrying out the experiments. An investigation is made of optical anisotropy in conditions of viscous flow, and a description is furnished of the simplest plane problems of viscous flow. Some methods used in the analysis of the experimental data are given. Demonstrations are put forward of the modelling treatment for cases of pressure-stamping and the extrusion and pressing in of stamps.

S. P. Shikhobalov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

745. Niskanen, E., On the distribution of shear stress in a glued single shear test specimen of Finnish birch timber (in English), State Inst. for Tech. Res., Finland, Publ. 36, 19 pp., 1957.

Direct continuation of the author's previous investigation, 1955 [AMR **9** (1956), Rev. 3222], in which the solution was obtained with Fourier series, restricted however to the ratio $H:2c = 1$, $2H$ being the glued joint length along which the shear is distributed (timber thickness), and $2c$ the distances on each side from the shear section along which the uniform pressure p is acting. For other ratios than 1 the Fourier integral causes very elaborate numerical calculations. For this reason a more simple method based on the theory of elasticity, presented in this paper, was used and corroborated by experiments (for ratios 1/2, 2 and 3). Both theoretical and experimental results show clearly that the block shear test specimen conforming to American standards ($H:2c = 1$) gives the highest shear strengths. Of special interest are photoelastic tests carried out for the ratio $H:2c = 2$ (with isotropic specimens).

J. J. Polivka, USA

746. Dean, M., III, Strain gage waterproofing methods and installation of gages on propeller strut of USS Saratoga, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 137–150, 1958.

Paper describes new waterproofing techniques and materials for protection of strain gages and associated wiring. Certain synthetic rubber compounds and two wax products have been found to be very satisfactory waterproofing materials. Techniques for the use of these materials are described in detail. In addition to providing good waterproofing, the synthetic rubber compounds afford consi lerable mechanical protection from turbulent water flow, underwater explosion shock, particle abrasion, and direct mechanical contact.

Details are given for an entirely new method for protecting gages on the exposed surfaces of underwater ship hull plates and hull appendages. One of several such applications, consisting of five strain gage locations on one of the propeller-shaft struts of the USS SARATOGA, is discussed.

From author's summary

747. Gessen, B. A., Ring-shaped elastic systems for dynamometers with wire strain gauges (in Russian), *Trudi Moscow In-ta Khim. Mashinostr.* **11,** 173–186, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7273.

An investigation is described which was undertaken to determine the measurements of rings to which could be glued four wire strain gages orientated in a resistance bridge network.

From author's summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

748. Gratch, S. A., The problem of measuring the distortion of long-base strain gauges (in Russian), Dopovidi ta Povidomleniya, L'vov In-ta, no. 6, pt. 2, 104–108, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2512.

A method is suggested for calculating the influence of the base length of the strain gage on experimental confirmation of the theoretical results in the analysis of problems of elasticity in flat plates (slabs).

From author's summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

749. Mizyumskii, V. A., An experimental method of determination of rock pressures in tunnels (in Russian), Vopr. Geotekhniki, Moscow, Transzheldorizdat, 1956, 165–184; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1048.

Stresses at some points of the temporary reinforcements of the subterranean excavations are proposed to be measured experimentally to determine diagrams of rock pressures along wooden frameworks. In cases of metallic or cast-iron casings of tunnels it is proposed to determine deformations, and from them stresses, by means of strain gages which, due to especially difficult subterranean conditions of work, must be of special reliability.

Two cases of experimental investigations performed by the author are described for determination of vertical rock pressures. In the first test two double-T steel beams were investigated which

formed the top reinforcement of a shaft of a span of 3 m; in the second case two rings of the circular cast-iron casing of a tunnel were examined whose external diameter was equal to 2.4 m. This tunnel was constructed at a depth of 16.5 m in a very weak clay.

The examined method of determination of rock pressures on temporary reinforcements evidently has no advantage over the known method of determination by strut dynamometers, but in case of the cast-iron ring casing of tunnels the proposed method of determination of pressures by strain-gage pickups appears to have advantages.

S. S. Davydov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

750. Rembowski, J. L., Theory for the calculation of the tangential residual stress distribution in curved beams, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 195–198, 1958.

If a thin annular layer of material is removed from a residually stressed curved beam, the resulting change in the curvature of the beam can be used to determine the initial residual stress distribution. Author does this by assuming that the residual stresses in the radial and axial directions are negligible. The computations are lengthy and the experimental work requires fine precision measurements. Reviewer believes that the effect on the bending moment of the radial stresses may not be negligible because the radial stresses are necessary for static equilibrium of the removed thin layer.

N. C. Costakos, USA

Material Test Techniques

(See also Revs. 588, 722, 726, 745, 750)

751. L'vovskii, M. Ia., and Smiian, I. A., A new method for testing the resistance to thermal shock of heat-resistant sheet materials, *Indust. Lab.* **24,** 2, 213–215, Mar. 1959. (Translation of *Zavod. Lab. SSSR* **24,** 2, 202–203, Feb. 1958 by Instrument Soc. Amer., Pittsburgh 22, Pa.).

Authors give brief account of technique for measuring the comparative resistance of sheet materials to thermal shock. Specimen is in form of narrow tapered strip 185 mm long with an accurate notch cut in center of wider end (20 mm wide). Equipment is provided for automatically retaining strip in electric furnace until temperature at notched end, recorded by thermocouple on specimen, reaches preset value. Strip then is dropped by solenoid into quench bath and cycle repeated. Cycle time in heating bath is approximately 1 min and in quench 5 sec. End point of test is when crack spreading from notch measures fixed length. Apparatus is designed for metal testing and results on a Nichrome alloy are given for temperatures 800–1200 C.

K. W. Hillier, England

752. Urvantsov, L. A., and Timofeev, E. I., Investigation of metals under impact-tension at different temperatures (in Russian), *Zavod. Lab.* **23,** 2, 238–242, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1391.

A method is described of dynamical stretching of metals at low (down to −60°) and high (up to 1200°) temperatures. Loading is applied by means of a pendulum impact machine. The change of value of stress during the process of impact-tension is measured by means of a dynamometer fixed on the pendulum carrying a strain gage, the output of which is demonstrated by an oscilloscope and recorded on a photographic film. The heating of samples was achieved by a flow through them of electric current from a low-voltage welding transformer. Characteristics of strength and plasticity were calculated from the usual formulas, and the loadings which corresponded to the limit of strength and to the true resistance to destruction were calculated from oscillograms of the impact-tension, from which the time of the destruction of samples could be fixed. The characteristics of strength of the 30KhNZM steel obtained in these tests gave higher values than those obtained in static tests (by 3 to 20%), with a tendency to decrease while the temperature rises.

G. A. Tulyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

753. Kolgatin, N. N., Glikman, L. A., and Teodorovich, V. P., Experimental procedure for prolonged testing to destruction of tubular test samples under internal pressure by hydrogen at high temperatures (in Russian), *Zavod. Lab.* **23,** 9, 1098–1101, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7227.

Results are given of tests carried out on tubular test samples made from steel mark 20 and also from steels mark NM1 and 1Kh 18N9T. To bring out the special features of the influence of hydrogen, parallel experiments were carried out with nitrogen. The tests showed that under hydrogen pressure the prolonged stability of steels mark 20 and NM1 is significantly lowered. For the austenite steel mark 1Kh 18N9T at temperatures up to 600° there was no sign of the lowering effect of the hydrogen in prolonged testing up to 2500 hours.

A. D. Pospelov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

754. Sistiaga, J. M., Residual stresses of metals. Part I, Their determinations, Part II, Methods of determination (in Spanish), *Rev. Cienc. Apl., Madrid* **12,** 5, 385–396, Sept.–Oct. 1958; **12,** 6, 496–507, Nov.–Dec. 1958.

Clear comprehensive review starts with definition of residual stresses and covers qualitative and quantitative methods for their determination. Destructive, semidestructive methods of mechanical type and x-ray diffraction are included.

C. Riparbelli, USA

755. Gladkovskii, V. A., and Oleinik, M. I., An apparatus for the investigation of the mechanical properties of metals when under high hydrostatic pressure (in Russian), *Fiz. Metallov i Metalloved.* **4,** 3, 531–535, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7268.

Authors describe the design features of an apparatus for testing samples at hydrostatic pressures up to 10,000 Kg/cm². The automatic recording of the curve in terms of coordinate "force-deformation" was effected by devices consisting of resistance wire strain gages, of a multichannel electronic amplifier, and a Duddell oscillograph. An experiment using beryllium bronze established that hydrostatic pressure raises the limit of flow quite significantly, but the increase of stress with increase of deformation at high pressures was much slower than at atmospheric pressure.

G. A. Tulyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

756. Tenenbaum, M. M., Testing the scratch resistance of metals, *Soviet Phys.-Tech. Phys.* **2,** 5, 1006–1015, Feb. 1958. [Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 1106–1117, May 1957 by Amer. Inst. Phys., Inc., New York, N. Y.].

Article gives the results of an investigation into the scratch method using a trihedral diamond point for testing the mechanical properties of metals and alloys, as distinct from the properties determined by microhardness. A criterion for estimating scratch resistance has been selected and established, and the relationship between the characteristics of hardness determined by scratching and indentation methods is shown for pure metals and carbon steels. The existence of a relationship between the scratch re-

sistance of materials and their wear resistance is shown for several forms of abrasive action on the tested material.

From author's summary

757. Venkataraman, S., Design of continuous centrifuge, *J. Sci. Engng. Res., India* **2,** 1, 1–9, Jan. 1958.

The essential parts of a continuous centrifuge are the filtering section, draining section where the entrained moisture in the cake is removed, the device for the movement of the cake across the centrifuge and the drive. The usual filtration and dehydration equations have been modified to suit them for the design of centrifuges. The performance of a centrifuge can be predicted with the aid of the above equations. They also aid the design of centrifuges for any specific duty. The method is illustrated by a worked example. From author's summary

Properties of Engineering Materials

(See also Revs. 594, 595, 616, 618, 722, 730, 739, 745, 751, 910, 911)

758. Chatterjee, G. P., Vibration damping characteristics and anelastic behavior of low carbon steel, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 16–23.

Paper presents results of (1) measurements of hysteresis in slow (100 psi per minute) tensile loading up to low (100 psi) maximum stress and (2) measurements of specific damping capacity in torsion of 0.14C steel. Author concludes there is "measurable anelasticity even at low stress levels" and that "damping capacity is extremely structure sensitive."

H. J. Grover, USA

759. Harmon, E. L., Kozol, J., and Troiano, A. R., Mechanical properties correlated with transformation characteristics of titanium-vanadium alloys, *Trans. Amer. Soc. Metals* **50,** 418–436, 1958.

760. Fortney, R. E., and Avery, C. H., Effects of temperature-time histories on the tensile properties of airframe structural aluminum alloys, *Trans. Amer. Soc. Metals* **50,** 814–828, 1958.

761. Spachner, S. A., and Rostoker, W., The mechanical properties of forged chromium, *Trans. Amer. Soc. Metals* **50,** 838–852, 1958.

762. Pond, R. B., and Harrison, Eleanor, Grain boundary movement in bi-crystalline aluminum, *Trans. Amer. Soc. Metals* **50,** 994–1003, 1958.

763. Belyankin, F. P., Kolenchuk, K. I., and Yatsenko, V. F., The protracted resistance of wood (in Russian), *Sb. Tr. In-ta Stroit. Mekh. Akad. Nauk USSR* no. 21, 103–114, 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7241.

The reliability and means available for the determination of the limit of protracted resistance of wood are examined. The selection of time bases for use in its determination is justified; a method is put forward for its evaluation in a complex stressed state in accordance with data derived from tests on tension and compression. A description is given of an experimental trial of this method for a case of pure deflection. Curves for the experiments carried out on the protracted resistance of pine, oak and beech are put forward to cover tension, compression and shear along the grain, and also pure deflection.

B. N. Ugolev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

764. Bogdanovich, A. F., A quicker method for the determination of the limit of endurance of pine wood during compression along the grain (in Russian), Investigations on the strength and tendency to deformation of wood, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1956, 153–166; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7243.

The existence was demonstrated of two regions of deformation when carrying out tests with a pulsating load. In the first region during a constant pulsating load the curve of increase of deformation approaches asymptotically the determined limit with increase in the number of loading cycles. In the second region the deformation increases continuously with no damping. For the determination of "the proposed limit of endurance" P tests were carried out with a stepwise increasing load with different numbers of the cycles of loading at each step. The lowering of P with increase in the number of cycles was established. With a small number of cycles on a step P approaches the limit of plastic flow, determined by the usual machine tests. The value of P depends essentially on the magnitude of the coefficient of asymmetry (the relation of the lower pulsating load to the upper).

B. N. Ugolev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

765. Knezevic, M., Influence of the angle of cut of grains on the compression and bending strength of oak (in Serbocroatian), *Shumartvo* **9,** 11/12, 667–687, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1429.

766. Narayanamurti, D., Some aspects of the rheology of adhesives, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 111–128.

Author presents results of determination, by previously known methods, of such properties as viscosity, setting time, elastic moduli of such adhesives as gelatin, casein, and urea-formaldehyde. H. J. Grover, USA

767. Smyth, H. T., Elastic properties of glasses, *J. Amer. Ceram. Soc.* **42,** 6, 276–279, June 1959.

By assuming that a silicate glass is a continuous network of silicon-oxygen tetrahedra joined at the corners, and that the only work done in deforming the glass is in the stretching or shortening of Si-O-Si links, author shows that Poisson's ratio should be 0.25. This agrees with experiment for most silicate glasses. Lower values can be explained by taking into account distortion of the tetrahedra, and larger values by the presence of large modifying ions in the interstices. A. D. Topping, USA

Structures: Simple

(See also Revs. 620, 622, 626, 635, 654, 668, 733, 740, 745, 974)

Book—768. Hirschfeld, K., Structural engineering, theory and examples [*Baustatik, Theorie und Beispiele*], Berlin, Springer-Verlag, 1959, xvi + 823 pp. DM 76,50.

Book constitutes a text and reference book suitable for fourth-year as well as beginning graduate students in structural engineering. Throughout, it is lucidly written and contains many completely solved numerical examples for student study as well as an entire chapter of problems to be worked by the student.

The first two chapters constitute a review of the definitions of indeterminateness, influence lines, and common methods of construction of influence lines by graphical techniques. The third chapter discusses virtual work and virtual displacements as applied to problems of indeterminate beams and redundant frame-

works. The theorems of Betti, Maxwell, and Castigliano are discussed in detail and illustrated by applications involving beams and frames. The fourth chapter briefly reviews techniques for solving systems of linear algebraic equations. The fifth chapter, whose length is almost half that of the entire book, deals with the analysis of statically indeterminate systems of beams, rings, trusses, bents, frames, and grillage systems. Virtual displacements as well as the three moment equation are employed extensively. The method of fixed points is also introduced and illustrated. Iteration techniques are discussed briefly and applied to continuous beams as well as frameworks.

The sixth chapter presents a discussion of beams on elastic foundations, as well as axisymmetrically loaded circular plates on elastic foundations. The treatment is limited to linear, small deformations. The seventh chapter is a collection of problems to be worked by the student and the eighth chapter contains various tables to assist in the analysis of indeterminate beams and frameworks, and in the formation of influence lines.

The presentation is limited exclusively to classical method of structural analysis and does not introduce more recent developments, such as matrix methods of analysis. Also, energy methods of analysis are treated only briefly. W. A. Nash, USA

Book—769. Morice, P. B., Linear structural analysis, New York, Ronald Press Co., 1959, xii + 170 pp. $6.

As the title of the book implies, it is confined to the equilibrium analysis of linear elastic structures. Author states in the introduction that the changes in geometry of the structures under load are assumed to be sufficiently small so as to have a negligible effect upon loads and their corresponding stress distributions; and the structural materials are assumed to obey Hooke's Law.

The object of the book appears to be one of setting forth in a systematic manner the applications of matrix algebra and influence coefficients to linear structural analysis. The first three chapters are devoted to basic concepts of strain energy, influence coefficients and indeterminancy. Chapter 4 reviews some of the elementary properties of matrices and Chapter 5 is devoted to methods of numerical computation by means of matrices. Chapters 6, 7, 8, 9 and 10 are entitled Scale factors; Stress resultant distributions, Lack of fit and settlement; Some transformations; Release System Relations; and The flexibility matrix, respectively. Chapter 11 discusses machine analysis, and a 20-page appendix is devoted to four illustrative examples drawn from civil engineering.

Throughout the book the author stresses the two complementary formulations of a structural problem, namely: (1) The stiffness method in which geometrically compatible states are combined to give equilibrium. (2) The flexibility method in which equilibrium states are combined to give geometrical compatibility. Since the author's interests are primarily civil engineering the numerous examples presented are drawn from that field. He points out, however, in the Preface that the same methods may be employed in other fields such as aeronautical structures.

On the whole, the book is well written and author has without question succeeded in producing a useful reference book which sets forth in a systematic way the applications of matrix algebra and influence coefficients to linear structural analysis. The numerous illustrations and examples will make the book especially useful as a reference book for practicing engineers.

The references are predominately British, with four references to American textbooks. It is regretted that some acknowledgment or consideration could not have been given to the very extensive applications in this field made by the American aircraft industry and American research establishments since the end of World War II. R. L. Bisplinghoff, USA

Book—770. Umanskii, A. A., The statics and kinematics of frameworks (in Russian), Moscow, Gostekhizdat, 1957, 342 pp. + illus. 13r. 10k: *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8133.

The author's lectures and research into the theory of plane and three-dimensional statically determinable frameworks, both of rods alone and also with a thin wall, are given in sequence in the book, which contains 7 chapters and a bibliography. Chapter I contains a review of the basic problems of the statics of plane frameworks —the development and calculation of the simplest frameworks, the plotting of the mutual diagrams for such frameworks, the various cases of the securing of a disk by three rods, and the evolution of simple disk systems; the statics of different disk systems, which are a generalization of the three-joint arch, are also examined. Examples of the graphical calculation of disk systems are reviewed. A number of examples are used to illustrate the idea of the transformation of systems and calculation by the method of rod replacement. Chapter II is devoted to determination of the displacements, and to the kinematic method of determining the forces in plane frameworks. The basis is the principle of the possible displacements. The properties of the polar and local diagrams (the polar and non-polar plans) for displacements of the hinged-rod system units, caused by the elongation of one or several rods, are investigated. Particular attention is paid to the plotting of a diagram portraying the displacements of an absolutely rigid disk in its plane. Complicated cases of the drawing of diagrams for frameworks are investigated. The coordinates of the units of the deformed framework are given analytically. The following theorem is proved using the concept of the virial of a balanced system of forces: for a girder framework under vertical loading, the algebraic sum of the products of the forces in the components and their length is positive, equal to zero, or negative depending on whether the load is applied below a straight line joining the points of support, at the same level, or above it. The representation of the displacements of a plane disk system in its plane by means of the sliding vector for the angle of rotation φ, perpendicular to the plane, and the free vector of the forward displacement Δ, is investigated. An equation is given for the possible work done by a system in which the disks are joined to each other by hinges or deformable rods.

Chapter III is devoted to study of the securing of a three-dimensional hinged unit and a solid body, and to means of graphically determining the forces in the rods securing the unit or body. The particular and general cases of force resolution into components along the six supporting rods of the body are examined, while the calculation is performed in such a manner that the common equilibrium equations need not be solved. Chapter IV is confined to the analytical statics and kinematics of small displacements of a solid body in space. In this chapter the problems are solved by means of force and displacement motors. These three-dimensional cases are determined, expressions are given for the possible work and the scalar product of the motors, and the motors are resolved into orthogonal motors. Examples of the determination of reactions and forces by means of a motor are then investigated, also the development of a possible displacements and an influence motor. Three graphical motor theory methods are given in Chapter V. A method of motor presentation such that the main vector and the main moment are represented by two different vectors is introduced. This is achieved by introducing portrayal or transforming motors, operations which are used to replace operations with the prescribed motors being portrayed. Two types of transformation are set out with their geometrical forms. The use of these methods to solve the basic problems in three-dimensional statics is indicated.

In Chapter VI the methods indicated are applied to the calculation of three-dimensional frameworks—plotting the surface effect of the forces. The "modelling method," a method based on the transformation of the prescribed framework, is elaborated upon, and its numerous applications shown. Chapter VII introduces an object of more general aspect—a thin-walled framework, i.e. a framework whose components are not only rods but also thin plates—

into structural mechanics. Under specific conditions these systems may be statically determinable. A number of examples of the calculation of such systems are given. On the whole, the book contains much new and original material.

I. M. Radinovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

771. Halbritter, F., Inclusion of the torsional stiffness of boundary supports in structural frames (in German), *Beton u. Stahlbeton.* **53**, 10, 267–271, Oct. 1958.

The boundary of a vertically loaded plate (or gridwork) resting on an orthogonal network of columns is stiffened by a bar. The torsional rigidity of the bar and its influence on the reactive moments distribution along the boundary frame is discussed.

M. Sokolowski, Poland

772. Il'enko, O. V., Designing and modelling of certain three-dimensional frames by the use of electrical systems of substitution (in Russian), Electric modelling of beams and frames, Taganrog, 1956, 42–49; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7028.

A tri-polar system of substitution for bending beams and a scheme of substitution for a beam in torsion enable the author to work out a calculation procedure for three-dimensional beams with the help of electric analogies (the method of electrical analogy). Some examples are given of the calculations.

K. K. Kerolyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

773. Rozenblyum, V. I., Some problems of the creep analysis of metal structures (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Leningr. Politekhn. In-ta, Leningrad, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2179.

774. Moliotis, P. D., A general method of analysis of rigid frames, *Trans. Amer. Soc. Civ. Engrs.* **122**, 950–972, 1957.

Author states that "by new factors of distribution and transmission a quicker and simpler solution is obtained" when compared with standard methods of moment distribution. However, paper is essentially a neat tabular presentation of moment distribution and leads, in some cases, to more operations (e.g. author's third example). J. Heyman, England

775. Ceradini, G., Some reflections about iteration methods in framed structures computation (in Italian), *G. Gen. Civ.* **95**, 7/8, 572–615, July/Aug. 1957.

Very interesting analysis of problems concerning calculation of continuous framed structures, with or without sidesway, clearly shows substantial equivalence between Cross and Grinter methods and iteration solution of systems of equations involved. Convergence of iteration is studied in different types of structures. New scheme of analysis with reduced equivalent frames is proposed in cases of slow convergence, this scheme being often convenient for first approach to dynamic problems. Accelerating process of convergence, in frames without sidesway, is presented that is also useful when several kinds of changes are to be considered. Some numerical examples are given.

F. Correia de Araujo, Portugal

776. Pagano, M., Calculation of continuous frames with sidesway, by inserting auxiliary internal connections (in Italian), *G. Gen. Civ.* **95**, 7/8, 616–623, July/Aug. 1957.

Inserting auxiliary internal connections in some types of frames with sidesway allows a remarkable convergence when Grinter method is used, all the computation being made in only one scheme of the structure. A numerical example is given to show the advantage of this artifice.

F. Correia de Araujo, Portugal

777. Wang, C.-K., Matric analysis of statically indeterminate trusses, *Proc. Amer. Soc. Civ. Engrs.* **85**, ST 4 (*J. Struct. Div.*), 23–36, Apr. 1959.

Paper reviews the use of matrix algebra as applied to truss analysis. The approach is to cut the redundant members, analyze the resulting determinate system and resolve deflection incompatibility by application of redundant forces. All of this is done automatically by following the matrix program presented which yields, in turn, the internal forces, reactions and deflections of the truss. The procedure is best suited for high-speed digital computers. J. A. Cheney, USA

778. Cooper, B. F. C., Automatic compensation of structural deflections, *Austral. J. Appl. Sci.* **10**, 1, 45–64, Mar. 1959.

An experiment is described in which the deflections of a cantilever truss, produced by loading it at three points, were automatically compensated by a system of three servomotors. The servomotors were controlled by photoelectric cells, mounted at the three load points, which detected deflections of the truss relative to a fixed beam of light. The dynamics of the system are analyzed, and the stability criterion for systems of this type, containing a multiplicity of interacting servomechanisms, is discussed.

From author's summary by R. M. Evan-Iwanowski, USA

779. Chapman, J. C., and Slatford, Jean E., Design of stiffened plating in compression, *Engineer, Lond.* **207**, 5378, 292–294, Feb. 1959.

Simple formulas governing the buckling of simply-supported stiffened plating are applied to some practical examples which may be relevant to ship design. The variation in critical stresses caused by changing the distribution of the stiffening members between the transverse and longitudinal directions is illustrated. For the transversely-stiffened plate selected it is concluded that, by introducing longitudinal stiffeners and reducing the transverse stiffening, the total weight can be reduced by 8 per cent while maintaining the same overall buckling load. A greater saving can be achieved by reducing the plate thickness. Alternatively, by maintaining the same weight the overall buckling load can be increased three times. The buckling stress of a single panel of plating is also increased when longitudinal stiffeners are introduced. When considering the implication of longitudinal stiffening, it should be borne in mind that the postbuckling reserve of strength (in the elastic range) is less when longitudinal stiffeners are employed. No consideration has been given either to postbuckling behavior or to the effect of transverse bending.

From authors' summary

780. Kelsey, S., Gellatly, R. A., and Clark, B. W., The shear modulus of foil honeycomb cores—A theoretical and experimental investigation on cores used in sandwich construction, *Aircr. Engng.* **20**, 356, 294–302, Oct. 1958.

Upper and lower limits to the shear modulus honeycomb sandwich cores are obtained by application of the unit-displacement and unit-load methods in conjunction with simplifying assumptions as to strain and stress systems respectively in the core. Theory given applies to foil ribbons forming general honeycomb cells. All cells are assumed identical in size and shape and symmetrical about longitudinal and transverse centerlines. Core elements are assumed taking only (constant) shear stress in the plane of individual foil panels. Thickness of foil is small and effect of finite cell corner radius is negligible.

Different test methods are discussed. The three-point bending test is considered to be more satisfactory than the single or double block shear tests and than four-point bending tests for determining the shear modulus.

Permitted tolerances in normal manufacture on both foil thickness and cell dimensions can cause differences in shear modulus

up to 25%. For standard form of cell, regular hexagon, the difference between the two theoretical values is small in comparison with effect of tolerances. For design use a mean of the result of the force and displacement methods gives satisfactory accuracy. At large cell angle the theoretical range is increased. More precise information would require further tests.

E. R. Steneroth, Sweden

781. Borges, J. F., and Lima, J. A. E., Remarks about the design of reinforced concrete beams, Minis. Obras Publicas, Lab. Engen. Civ., Lisboa, Publ., Tech. Pap. 122, 14 pp., 1958.

Some results of bending tests of concrete beams reinforced with normal and twisted steel are presented. Interpretation is made of cracking, deformability and rupture.

As for cracking it is verified that, in order to prevent too wide cracks, it is necessary to limit the ratio between the diameter of the bars and the percentage of reinforcement.

Concerning deformability, the analysis of scattering that it was possible to make has shown that scatterings were considerably different for the beams reinforced with mild and twisted steel.

Finally, regarding rupture, the results obtained agree with those foreseen by the existing theories.

It seems of interest, nevertheless, to carry out studies which, taking into account the randomness of the mechanical properties of the materials, make it possible to foresee the statistic behavior, not only in relation to rupture but particularly in relation to deformation.

From authors' summary

Structures: Composite

(See Revs. 592, 635, 637, 643, 671)

Machine Elements and Machine Design

(See also Revs. 580, 682)

782. Tainov, A. I., Hyperboloid system cam mechanisms (in Russian), *Sb. Naucbn. Trudt Belorussk. Politekhn. In-ta* no. 57, 3–14, 1957; *Ref. Zb. Mekb.* no. 7, 1958; Rev. 7398.

Article examines the structure of the mixed family of mechanisms containing a single first class couple and an unlimited number of second class couples; the ways of producing them are reviewed. The plotting of the diagrams for the simplest and complicated hyperboloidal system cam mechanisms by the successive superposing of normal type groups of the first family in this system, or by superposing complex groups, is shown.

M. K. Kristi

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

783. Seeliger, K., Epicyclic gear trains in variable speed transmissions (in German), ZVDI **101**, 6, 217–224, Feb. 1959.

784. Predale, J. O., and Hulse, A. B., Jr., Space crank . . . . a new 3-D mechanism, *Prod. Engng.* **30**, 9, 50–53, Mar. 1959.

This three-dimensional rival to the 4-bar linkage can replace various linkages and cams in automatic machines. Design variations of such a crank are shown, also equations and curves of its displacement, velocity, and acceleration characteristics.

From authors' summary

785. Hunt, K. H., Dwell-linkages in space, *Engineering* **187**, 4850, 248–249, Feb. 1959.

786. Ponomarev, I. G., Principles applied in designing of a hinged four-link mechanism (in Russian), *Trudt Tul'sk. Mekban. In-ta* no. 8, 125–142, 1958; *Ref. Zb. Mekb.* no. 10, 1958, Rev. 10823.

Author submits an analytical method for designing four-link mechanisms, making his starting point Grashof's condition (the capacity to pull) and, in addition, taking into account one of the following conditions: (1) safeguarding the rotation of the balancing arm to the given maximum angle; (2) safeguarding the given minimum angle of transmission; (3) safeguarding the given magnitude for the coefficient of change of velocity of the driven link.

V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

787. Murthy, S. N. B., Lay-out of four-bar and derived mechanisms for quick-return motion (in English), *J. Sci. Engng. Res., India* **1**, 2, 161–168, July 1957.

The lay-out of four-bar linkages for quick-return motion is complicated by the relation between the angle of swing of the lever and the difference in crank rotation during the forward and return strokes. Four such relationships are assumed and the layout of mechanism illustrated. Some limits to the choice of such angles of swing and rotation have also been discussed with reference to increased uniform velocity in either direction of motion and to the minimum force required to be exerted by the crank at dead centers.

From author's summary

788. Shamburov, V. A., A new method of synthesis of pantographs and other transforming mechanisms (in Russian), *Trudt Sem. Teor. Mash. Mekb., In-ta Mashinoved., Akad. Nauk SSSR* **17**, 67, 5–21, 1957; *Ref. Zb. Mekb.* no. 10, 1958, Rev. 10825.

The general position is stated and the theory is developed on the analytical synthesis of transforming plane mechanisms, with the lowest pairs without the passive links in such chains, which are converted into a mechanism with two steps of freedom during the rigid locking of one link. The synthesis of pantographs is examined, and a general solution is given for the problem of the synthesis of the generally used types of plane hinged semi-link pantographs.

V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Fastening and Joining Methods

(See also Revs. 603, 745)

789. Munse, W. H., Petersen, K. S., and Chesson, E., Jr., Strength of rivets and bolts in tension, *Proc. Amer. Soc. Civ. Engrs.* **85**, ST 3 (*J. Struct. Div.*), 7–28, Mar. 1959.

A study was made to determine the fastener behavior in a tension-type structural connection assembled with either ASTM A-325 high-strength bolts or rivets of A-141 rivet material. In this study such factors as the flexibility of the connected members, the magnitude of the initial clamping force in the fasteners, the number of lines of fasteners, and the grip of the fasteners have been considered.

From authors' summary

790. Munse, W. H., Bell, W. G., and Chesson, E., Jr., Behavior of riveted and bolted beam-to-column connections, *Proc. Amer. Soc. Civ. Engrs.* **85**, ST 3 (*J. Struct. Div.*), 29–50, Mar. 1959.

The tests reported herein were performed as the first phase of an extensive program designed to study the general behavior of beam-to-column connections assembled with rivets or bolts and included four standard flexible connections. Three of the test specimens were assembled with rivets and high-strength bolts and

were tested at different moment-to-shear ratios. The fourth specimen was assembled entirely with rivets so as to provide a study of the effect of the type of fastener upon the behavior of the connections.

A study is made of the moment-rotation characteristics, the moment-resisting capacity, the position of the center of rotation, and the slip and shear deformation of the connections, the deformation of the fasteners, and the separation of the column flanges.

The tests reveal that the connections, although assumed for design purposes to behave as simple supports, actually provide some end restraint and that the restraint provided by the connections was increased slightly by the use of high-strength bolts in lieu of rivets to fasten the connection angles to the column flanges.

From authors' summary

791. Hanson, N. G., Fatigue tests of joints of high strength steels, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 3 (*J. Struct. Div.*), 51–69, Mar. 1959.

A condensed summary is presented of a program of fatigue testing, in direct tension, of joints made from structural steels having various properties. Rivets and high-strength (A 325) bolts were used as fasteners, but the middle plate of the double-lap specimens was always critical in fatigue. It is concluded that clamping force was the most important variable governing the fatigue strength of the joints tested. In the riveted joints, the variations of clamping force subordinated whatever superiority one steel has over another. Joints having high clamping force have high fatigue strength; the joints connected with high-strength bolts show much higher fatigue strength than those connected with rivets, even approaching the yield points of some of the steels.

From author's summary

792. Vasarhelyi, D. D., Beane, S. Y., Madison, R. B., Lu, Z.-A., and Vasishth, U. C., Effects of fabrication techniques on bolted joints, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 3 (*J. Struct. Div.*), 71–116, Mar. 1959.

A considerable amount of earlier investigation of the characteristics of structural joints assembled with high-tensile bolts was focused upon the possibility of slip in the range of currently used design stresses. Other tests clarified the behavior of such joints under fatigue loads.

Some questions about the possible effects of various fabricating processes still were open, some others arose as new techniques and ideas developed both in methods of tightening the fasteners and in design principles. The question of the efficiency of joints being influenced by such factors as punching of the holes, misalignments and the paint on the faying surfaces has been left for the present investigations.

The high practical value found in the one-turn-of-the-nut method drew the attention to its possible effects upon the behavior of joints. This was especially so in the case of large and long joints, in which the gradual development of slip required more insight into the behavior of such joints.

A certain tendency toward considering the coefficient of friction in the design of the joint made a more thorough study of this factor necessary. Thus the threefold scope of the later investigations conducted on high-tensile bolted joints.

Tests on joints with drilled and with misaligned punched holes, both with mill scale and with painted faying surfaces showed that, as expected, the punching of the hole does and the misalignment and the paint do not affect significantly the efficiency of the joint. The effect of punching of the holes proved to be the same for bolted joints as for riveted ones. As a matter of fact, the efficiency of the bolted joint, in view of these effects, can be sufficiently predicted by formulas used to estimate the efficiency of riveted joints. The condition of the faying surfaces, whether painted or unpainted, apparently does not affect the efficiency.

A sufficient number of small (4 bolt) joint tests and a series of tests on large joints proved that the one-turn-of-the-nut method acts the way it would be predicted from the presence of the higher clamping force.

Systematic analysis of all available data on slip tests throws more light upon the behavior of the coefficient of friction in the joints. It shows that the major factor determining its value is the treatment of the faying surfaces. Such factors as clamping force, tension : shear ratio, etc., have well-defined but only minor influence on the value of the coefficient of friction.

These results and others should be of great value in the drafting of specifications for joints assembled with high-tensile bolts.

From authors' summary

793. Ball, E. F., and Higgins, J. J., Installation and tightening of high-strength bolts, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 3 (*J. Struct. Div.*), 117–131, Mar. 1959.

Paper describes the procedures which have been used by Bethlehem Steel Company to insure that high-strength bolts are installed and tightened to produce the minimum bolt tension required by specifications. It outlines the studies and tests that have been made to develop a safe, practical, and economical method of bolt tightening. Details of present procedures are described and illustrated.

From authors' summary

794. Kinney, J. W., Experience with high-strength bolts in the Mackinac bridge, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 3 (*J. Struct. Div.*), 133–144, Mar. 1959.

A brief description of the project is given, and details are described as to the particular application of bolted connections. The procedure for bolting and inspection as developed on the project is outlined. Some of the more common troubles are described and illustrated. Conclusions resulting from experience on the project are drawn.

From author's summary

795. Kodrov, A. I., Influence of some technological defects in carrying out the welding of joints on their strength (in Russian), *Trudĭ Vses. N.-i. In-ta Transp. Str-va* no. 24, 195–286, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6100.

Tests of butt-welded seams without removal of the (stress) forces showed that the presence of pores (with the exception of separate, very large pores or group of pores) does not exercise any noticeable influence on the "life" of the weldings. Tests of butt-welded seams with removal of the forces gave different results. Porosity in the shape of individual large pores and their chains showed marked influence on the shortening of the "life." In butt-welded seams with slag inclusions the formation of the initial crack, in a number of cases, did not lower to any appreciable extent the efficiency of the seams, which were able to resist a large number of supplementary loads. The slag inclusions coming up to the surface reduced the life of the seams to a much greater degree than the inclusions going inwards. Disruption at room temperature had a plastic character, while at a low temperature it was brittle, but the pores, and also the preliminary fatigue loads did not indicate appreciable influence on the conditions of disruption under static forces. The most powerful concentrators of stresses proved to be the pores coming out on the surface, causing a significant scattering in the "life" value. Tests under static loads of the joints with belt seams, possessing defective features at room temperature and at 50°, gave satisfactory results in relation to the value of the limits of yield and strength.

G. A. Nikolaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

796. Duchinskii, B. N., Strength of welded joints when under mainly compression (stresses) (in Russian), *Trudĭ Vses. N.-i. In-ta Transp. Str-va* no. 24, 162–194, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6107.

The experimental data obtained when investigating the subject given in the title are described. A diagram is drawn for the endurance (2 million cycles) of steel type M.16.S in regard to its flange joints and its lateral angle seams. Methods of calculations are looked into for the endurance of railway bridges according to the standards SShA and FRG, and a comparison is made with the SSSR standards (TUPIM-sv-55). It is shown that the standard requirements of American standards in comparison with those of the SSSR and FRG and of other countries are out of date: the stress tolerances appear to be lower in comparison with SSSR and FRG standards. I. A. Moiseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Rheology

(See also Revs. 740, 766, 767, 920)

797. Coleman, B. D., and Noll, W., On helical flow of general fluids, AFOSR TN 59-506 (Mellon Inst. Rep.; ASTIA AD 215 931), 24 pp., May 1959.

The relationship between the velocity field in helical flow (the flow between infinitely long concentric cylinders in relative rotation under the action of an axial pressure gradient) and applied forces and geometry is derived assuming that the fluid is an incompressible "general fluid." The definition of "general fluid" [W. Noll, *Arch. Rational Mech. Anal.* **2**, 3, 197-226, 1958; AMR **12** (1959), Rev. 5062] is sufficiently general to include, for instance, fluids which exhibit long-range hereditary effects. The relationship involves only three material functions which appear capable of straightforward determination by rheological measurements. This seems an improvement over Rivlin's solution [AMR **9** (1956), Rev. 2919] which requires eight material functions with a less general definition of the fluid. S. Gratch, USA

798. Jain, M. K., On rotational instability in visco-elastic liquids, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957; 217-224.

The rotational instability of certain highly viscoelastic liquids has been studied by considering the special constitutive equations

$$S^i{}_j + \gamma \overset{\nabla}{S}{}^i{}_j = 2\mu d^i{}_j \qquad [1]$$

$$\rho\left(\frac{\partial v^i}{\partial t} + v^i{}_{>j} v^j\right) = -p_{>j} + S^{ij}{}_{>j} \qquad [2]$$

where

$$\overset{\nabla}{S}{}^{ij} = \frac{\partial S^{ij}}{\partial t} + S^{ij}{}_{>k} v^k - S^{ik} v^j{}_{>k} - S^{kj} v^i{}_{>k}$$

is the rate of stress tensor,

$$2 d_{ij} = v_{j>i} + v_{i>j}$$

is the rate of flow tensor, v_i is the velocity vector and p is the mean pressure. γ is an elastic parameter and μ is a coefficient of shear viscosity.

A variational procedure is used to solve the underlying characteristic value problem. It is found that the effect of the presence of elastic elements in viscoelastic liquids is to inhibit the onset of instability, the inhibiting effect depends on a nondimensional number Q which is proportional to the coefficient of elasticity.

For $Q = 0.01$, the increment in critical Taylor number which determines the onset of instability is about 8%.

From author's summary by J. M. Weiner, USA

799. Hirai, E., Theoretical explanation of heat transfer in laminar region of Bingham fluids, *AIChE J.* **5**, 1, 130-133, 8M-9M, Mar. 1959.

Service translation of paper in Japanese in *Chem. Engng., Japan* **21**, 17-25, 1957 is reproduced without figures, notation, references, tables or summary.

Author investigates heat transfer from a pipe to a Bingham material flowing within for the cases: (1) fully developed flow in pipe at constant temperature, (2) rod-like flow in pipe with maintained temperature gradient. Example is given for extrusion of a synthetic resin powder from a heated pipe.

Reviewer considers that papers of sufficient importance to merit translation from journals not widely available should never be emasculated by omission of figures, etc.

B. R. Morton, England

Hydraulics

(See Revs. 807, 808, 864, 884, 998, 999, 1012, 1016)

Incompressible Flow

(See also Revs. 797, 835, 839, 862, 863, 874, 892, 893, 920, 963, 971, 1003, 1032)

800. Pistolesi, E., and Marini, M., The aerodynamics of bodies in non-uniform flow—The aerodynamics of airfoils in non-uniform streams of incompressible fluid, AFOSR TN 59-111 (Univ. Pisa, Inst. Aero. TN 1; ASTIA AD 210 391), 18 pp., 1959.

The problem attacked is the plane problem of a lifting airfoil in a stream adjacent to another stream of different flow speed. The interface between the two streams is a rigid plate upstream of a certain finite distance upstream of the airfoil and is a free surface downstream of that point. The airfoil is now replaced by a single vortex and the equal-pressure condition on the free interface is linearized. The problem is solved by conformal mapping. It is interesting that a "Kutta condition" is needed at the rear edge of the boundary plate. Induced velocities at the airfoil location are used to determine, to first approximation, the lift of a given airfoil. In an appendix it is shown how the problem can be solved without conformal mapping, by function-theoretical methods.

W. R. Sears, USA

801. Pistolesi, E., and Marini, M., The aerodynamics of bodies in non-uniform flow—The aerodynamics of airfoils in non-uniform streams; subsonic and supersonic streams, AFOSR TN 59-112 (Univ. Pisa, Inst. Aero. TN 2; ASTIA AD 210 392), 20 pp., 1959.

The cases treated here concern an airfoil (vortex) in a subsonic stream adjacent to (a) a supersonic stream bounded by a plane wall and (b) a supersonic jet of finite width. The investigation is limited to linearized two-dimensional theory. The technique used is that of Fourier integrals. Considerable analysis is required to evaluate the integrals that result. The influence of the adjacent stream on lift of a given airfoil is determined by calculating the induced velocities at the location of the airfoil. Velocities at the interface and at the rigid wall and jet axis, respectively, are also calculated. W. R. Sears, USA

802. Fistolesi, E., and Marini, M., The aerodynamics of bodies in non-uniform flow—The aerodynamics of airfoils in non-uniform supersonic streams, AFOSR TN 59-113 (Univ. Pisa, Inst. Aero. TN 3; ASTIA AD 210 393), 39 pp., 1959.

These are calculations, by means of plane linearized theory, of the aerodynamics of a flat-plate airfoil at incidence in a super-

sonic stream (a) near an adjacent supersonic stream of different Mach number, (b) near the discharge of a supersonic jet whose discharge pressure equals the (undisturbed) stream pressure, and (c) near the discharge of an over- or underexpanded supersonic jet. Fourier-integral methods can be used, but more direct calculations following Mach waves through their generation and reflection are found to be simpler. In all cases the effect on lift is the major result calculated. W. R. Sears, USA

803. Smith, A. M. O., and Pierce, J., Exact solution of the Neumann problem. Calculation of non-circulatory plane and axially symmetric flows about or within arbitrary boundaries, Douglas Aircr. Rep. ES-26988, 106 pp., Apr. 1958.

Authors devise a numerical method for solving the second boundary-value problem of potential theory which consists in replacing the well-known integral equation formation of that problem by a system of algebraic equations. The method is applied to the determination of inviscid incompressible fluid flows about two-dimensional and axially symmetric bodies. The unknown in the integral equation formulation may be thought of as a source-sink distribution on the surface of the body. If this is considered to be a piecewise constant function s_k over intervals s_k, ($k = 1, 2, \ldots, n$) into which the arc length of the profile of the body is divided, then one obtains a system of n linear equations for the n unknowns s_k. These are usually solved by a modified Seidel method. It is claimed that the method gives very satisfactory results. Several examples are presented.

The paper is made overly long by a detailed discussion of several items which, although pertinent to the problem, are of the most elementary nature, and which one may properly assume to be known to the reader. W. H. Pell, USA

804. Weske, J. R., On the origin and mechanism of vortex motion at the inlet of intakes placed near a flat surface, AFOSR TN 58-863 (Univ. Maryland, Inst. Fluid Dynamics Appl. Math., TN BN-152; ASTIA AD 203 672), 24 pp., Nov. 1958.

In this important scientific paper the mechanism by which a vortex is formed in the field of a sink located close to a solid surface is examined both experimentally and theoretically. It is found that the problem is of instability of the boundary layer and that the secondary vorticity is the source of the vorticity removed by the vortex sink. Similar results hold good for twisters in a boundary layer and in the case of a vortex about an outlet in the bottom of a basin. In the latter case the reversal of vorticity at a branch point of a vortex stream tube is to be taken into consideration. B. R. Seth, India

805. Jaszlics, I., and Trilling, L., An experimental study of the flow field about swept and delta wings with sharp leading edges, *J. Aero/Space Sci.* **26,** 8, 487–494, 544, Aug. 1958.

Experiments were made in low-speed wind tunnel on two swept wings of constant chord and large aspect ratio and on a delta wing of 26° apex angle. All wings had sharp edges and boundary layers were turbulent. Swept wings had end plates to simulate flat-sided fuselage at wing root. Detailed measurements were made of velocity magnitude and direction and of pressure distribution. Also, vortex paths were traced by "vortometer."

Results show conical flow near wing root in all cases. On swept wings of large aspect ratio, edge of vortex sheet turns downstream when it reaches a chordwise position which is a fixed linear function of angle of attack. Outboard of this turning point the flow near the wing is nearly parallel to leading edge, with constant pressure. W. A. Mair, England

806. Seth, B. R., Non-linear rotational flows, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur 1957, 199–202.

A number of solutions of the vorticity equation $\nabla^2\Psi = \zeta = f(\Psi)$ are known for ζ = a constant, and for $\zeta = k\Psi$, k being a constant. These are all linear. It is shown that nonlinear solutions may be obtained for $\zeta = \exp(\Psi)$ and $\zeta = \Psi^2$. Particular cases of the former give rise to streamlines in the form of hyperbolic and Cotes's spirals which also occur as the path of a vortex in a space bounded by two perpendicular walls.

A particular case of $\zeta = \Psi^2$ gives a uniform flow open to atmosphere superposed on an infinite liquid in which ζ varies as $(y - c)^{-4}$. A general solution of the vorticity equation has also been obtained.

From author's summary by D. G. Huber, Canada

807. Walker, J. E., and Rothfus, R. R., Transitional velocity patterns in a smooth concentric annulus, *AIChE J.* **5,** 1, 51–54, Mar. 1959.

Velocity profiles are reported for water flow in an annular channel, with particular emphasis on behavior in the transition region. Data are shown for the variation of the radius-of-maximum-velocity with Reynolds number, and the relation of these results to the transition process is discussed. It is noted that results cannot be immediately generalized to annuli of different radius ratios, but can be applied to annuli of different sizes with the same radius ratio. E. W. Price, USA

808. Parkhomovskii, S. I., Impulsive symmetrical cavitational flow past a grid of plates, *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22,** 4, 794–799, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Analysis is confined to a single section of the grid in the form of a flat plate set symmetrically in the region between two parallel walls normal to the plate. The plate is given an impulsive forward motion into a stream of ideal fluid, setting up two-dimensional symmetrical cavitational flow. The impulsive force on the plate is determined, and numerical results exhibited graphically indicate how this force varies with certain nondimensional parameters dependent on the geometry and dimensions of the physical model and the characteristics of the undisturbed stream.

E. E. Jones, England

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 801, 802, 845, 850, 853, 854, 855, 877, 878, 879, 880, 883, 895, 896, 902, 931, 951, 952, 961, 968, 972, 973)

809. Hunter, H. E., An exact solution of the Navier-Stokes equations, *J. Aero/Space Sci.* **26,** 3, 181–182 (Readers' Forum), Mar. 1959.

Paper is a generalisation of another exact solution due to Chester [*J. Aero. Sci.* **24,** p. 853, 1957] for a fluid with constant viscosity and conductivity. In the solution the fluid has constant density and its motion may be interpreted as plane flow between two parallel planes whose distance apart varies with time, or flow through an expanding or contracting circular pipe. These solutions reduce to those of Chester for $\gamma = 1.5$ or $\gamma = 2$, respectively.

J. C. Cooke, England

810. Finston, M., A further note on aerodynamic heating (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 103–107.

Author considers the following unsteady heat-transfer problem for an infinite flat plate in a viscous fluid with constant properties. Plate is impulsively started from rest and moved parallel to itself with constant velocity. Using results of Emmons [AMR **4**(1951), Rev. 2571[and Bryson [AMR **6**(1953), Rev. 956] author

shows how complete solution involving heat conduction in both fluid and plate may be found. This is applied to find solutions for case when plate has infinite thickness and for case when plate has finite thickness and is insulated on side away from fluid. Results indicate that quasi-steady assumption can be made under conditions occurring in many practical situations.

R. C. Roberts, USA

811. Lehnert, R., and Schermerhorn, V. L., Correlation of base pressure and wake structure of sharp- and blunt-nose cones with Reynolds number based on boundary-layer momentum thickness, *J. Aero/Space Sci.* **26**, 3, 185–186 (Readers' Forum), Mar. 1959.

Correlations between base ratio and Re_θ, wake angle and Re_θ, derived from experimental work, are presented for flow past a sharp-nosed cone (10 degrees semivertex angle) and a spherical-nosed cone (0.5 bluntness ratio). (Re_θ = Reynolds number based on boundary-layer momentum thickness.) For detailed work refer to NAVORD Rep. 5668, 1958.

S. D. Nigam, India

812. Belen'kii, I. M., Quasi-stationary flow of a gas from a cylindrical container of variable volume, *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 2, 383–392, 1958. (Reprint order no. PMM 35, Pergamon Press, 122 E. 55th St., New York, 22, N. Y.).

813. Harris, K. D., Subsonic drag and pitching moment characteristics of slender cambered bodies, *Coll. Aero., Cranfield, Rep.* 118, 38 pp., Sept. 1958.

The experiments showed that nose camber produces a pitching moment increment in very close agreement with the predictions of inviscid slender body theory. The increments in lift and drag, while not zero as predicted by inviscid theory, are small. Tail camber on the other hand gives rise to much larger lift and drag increments, and the increment in pitching moment is quite different from that predicted by inviscid theory. In the present tests the pitching moment increment due to tail camber amounted to about 10% of the theoretical value.

From author's summary

814. Belova, A. V., Wing airfoil moment for high subsonic velocities (in Russian), *Ucb. Zap. LGU* no. 217, 124–143, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7477.

A precise equation is deduced for the moment of the aerodynamic forces acting on a specific wing airfoil in a subsonic velocity flow. In order to use the successive approximations method, author subdivides the system of equations for the motion of a gas

$$\frac{\partial \varphi}{\partial x} = \frac{\rho_0}{\rho}\frac{\partial \psi}{\partial y}, \qquad \frac{\partial \varphi}{\partial y} = -\frac{\rho_0}{\rho}\frac{\partial \Psi}{\partial x} \qquad [1]$$

into an infinite sequence of systems of equations [see Belova, A. V., *Ucb. Zap. LGU*, no. 217, 90–123, 1957]. She then turns to the independent variables of the plane of a circle of unit radius (ξ), and solves the systems of equations in the neighborhood of an infinitely distant point by the method described by S. A. Khristianovich [*Tr. TsAGI* no. 481, 1940]. For the n-system of equations, a recurrent expression is introduced. Author then turns to the independent variables of the plane (ξ) in the general equation for moment also, substitutes the results obtained in that equation, and makes the radius of the circle $|\xi| = r$, along which integration takes place, tend toward infinity. As a result, using the conclusions drawn in her above-quoted work, author obtains the following equation for the moment L:

$$L = \frac{\rho_\infty v_\infty^2}{b^2}\left[\pi\beta_1\left(1 + \frac{1}{\sqrt{1 - M_\infty^2}}\right) - \alpha_0\gamma\right] \qquad [2]$$

where v_∞ and ρ_∞ are the magnitudes of the velocity and density of the flow of gas at infinity,

$$b = \left(\frac{d\xi}{dz}\right)_\infty \qquad z = x + iy$$

β_1 is the imaginary part of the coefficient for ξ^{-1} when resolving $(w/w_0)^2$ into series in the region of $\xi = \infty$ (w is the flow velocity of an uncompressed fluid), and α_0 is a constant determining the position of the point relative to which the moment is calculated. The quantity $w_\infty \gamma/b$ is the circulation of the subsonic gas flow under examination. Where $M_\infty = 0$, the well-known expression for the moment of an airfoil past which an uncompressed fluid is flowing is obtained.

I. M. Yur'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

815. Rao, D. M., and Ramachandra, S. M., Suction and power requirements of a ventilated wall "half-nozzle" at transonic speeds, *J. Aero. Soc. India* **10**, 4, 63–69, Nov. 1958.

Experiments conducted with a slotted wall (9.4% open) and a perforated wall (18.2% open), fitted in a two-dimensional half-nozzle configuration (i.e. occupying one side only of a rectangular nozzle) and employing plenum suction, indicate suction flow requirements considerably in excess of the quantities needed by normal ventilated nozzles, in the Mach number range 0.8–1.05. Measurements of diffuser power show substantial benefits of employing suction with a half-nozzle. Effects of nozzle length/height ratio and divergence angle on suction and power are demonstrated, and it is shown that an optimum combination of divergence and suction can yield useful tunnel power reductions in the entire transonic speed range.

From authors' summary

816. Aslanov, S. K., The motion of a double wedge-shaped profile at a speed not exceeding that of sound, *Appl. Math. Mech. (Prikl. Mat. Mekh.* **22**, 4, 632–648, 1958. (Pergamon Press, 122 E. 55th St., New York, N. Y.)

Flows past symmetric wedge profiles are solved approximately in the hodograph plane by generalization of an incompressible flow. Exact equation of Chaplygin is applied. A stream function is constructed which has proper singularities at points where speed of flow approaches zero and the free-stream value. Stream function is also required to obey transonic similarity law and to possess Frankl's singularity at sonic speed. Obtained solution meets all usual requirements except in the supersonic region, the influence of which is neglected.

Computed examples show qualitative and quantitative agreement with experiments for stream Mach numbers between zero and unity.

C. P. Kentzer, USA

817. Spreiter, J. R., and Alksne, Alberta Y., Thin airfoil theory based on approximate solution of the transonic flow equation, *NACA Rep.* 1359, 37 pp., 1958.

See AMR **11** (1958), Rev. 537.

818. Gukhman, A. A., Gandel'sman, A. F., and Naurits, L. N., Hydrodynamic resistance in the transonic region of flow (in Russian), *Energomashinostroenie* no. 7, 10–14, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7542.

A new method is proposed for the hydraulic calculation of a channel in the transonic flow region, a method based on the assumption that the entropy alters in linear manner along the channel. The experimental data which are given (obtained when testing a single nozzle) do not contradict this hypothesis.

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

819. Ryzhov, O. S., On flows in the region of the transition surface, *Appl. Math. Mech.* (*Prikl. Math. Mekh.*) **22,** 4, 608–621, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author discusses solution in neighborhood of sonic line in axisymmetric nozzle using transonic approximation. When the axial velocity derivative u_x is constant on the axis, similarity solutions in variable $\xi = (x^2/r)$ are appropriate. Flow pattern is then qualitatively similar to plane case except that branch line is not a hodograph characteristic.

Case when u_x on axis has different (constant) values, A_1 and A_μ on left and right of sonic point, is then discussed. Similarity solutions in terms of ξ are still appropriate, and an ingenious discussion of solution curves shows that although velocity derivatives are discontinuous across upstream limiting characteristic (through sonic point) they are, except in one special case, continuous across downstream limiting characteristic. It also follows that $1 \leqslant A_1/A_2 \leqslant 2/(7 - 3\sqrt{5})$.

Reviewer believes that although case discussed is interesting it is a very special inverse problem. Also, in places, the argument is very condensed and not easy to follow.

H. C. Levey, Australia

820. Valiev, Kh. Kh., The flow about of a composite plate by a supersonic flow when the nonlinear principle of penetration is working (in Russian), Uch. Zap. Bukharsk, Gos. Ped. In-ta, Tashkent, 1957, 137–141; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10904.

An investigation is made on the two-dimensional steady potential supersonic flow past a plate A_1A_4 containing a permeable part A_2A_3. The angle of attack is less than the critical. The principle of the fall of pressure on the permeable part is assigned in the form of $\Delta p = a_0 v_i + b_0 v_i^2$, where v_i is the normal component of the velocity of suction, while a_0, b_0 are constants. Assuming that, with the exception of the centrally situated simple waves at points A_1 and A_3 above the plate and at point A_2 under it, the flow consists of portions of an even rectilinear current, author draws up the principles of conservation on the impact waves and the permeable portion of the plate. In the same way a system of algebraical equations is obtained, adequate for the purpose of finding all the unknowns, with the exception of the angle of attack α on the permeable portion. Author recommends a search for α by means of an approximate numerical method, with a type of selection that would satisfy the principle of the fall of pressure. There are many misprints. For instance, the sign should be changed before P_1/ρ_1 in formula (2.4) and before b_0 in (2.16); instead of v_2 in formulas (2.5, 2.6) v_3 should be substituted; in (2.5) the multiplier $x^{1/2}$ is redundant and does not suffice for the indicator $1/(x - 1)$ above $\rho^x p_\mu$ etc. No interpretation is given for the symbol M_{a2} in the formulas (2.19–2.23).

R. G. Barantsev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

821. Murthy, S. N. B., On the method of characteristics for supersonic flows with shock waves, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 131–140.

The method of characteristics applicable to unsteady flows is not applicable where continuity is broken as in supersonic flows with shocks. Where the density change across the shock is not greater than 15%, the assumption of isentropy has been known to lead to no large error in computation.

In the case of stronger shocks, it is now suggested that the method may still be applied by the assumption of a fictitious upstream pressure from which the end pressure can be reached without change in entropy and which gives a measure of the required change in the inclination of the characteristics. In regard to the changes introduced in the specific heat ratio of the gas by such strong shocks, it can be seen that up to a Mach number of 5, the order of corrections is negligible compared to other limitations of the assumptions.

From author's summary

822. Vinokur, M., Hypersonic flow around bodies of revolution which are generated by conic sections, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 232–253.

The flow around the family of bodies of revolution which are generated by conic sections is treated by neglecting variations in density. Two approximate analytic solutions are presented. In one, the shock wave is assumed to be locally confocal with the body. In the other, the shock curvature is assumed constant near the axis. Both solutions reduce to that of Lighthill in the case of the sphere. The results are compared with those of other theories, as well as with available experimental data.

R. C. Binder, USA

Book—823. Greene, E. F., and Toennies, J. P., Chemical reactions in shock waves (Chemische Reaktionen in Stosswellen) (Monographs in Physical Chemistry no. 3), Darmstadt, Dr. Dietrich Steinkopff Verlag, 1959, xv + 202 pp. DM 25. (Paperbound)

The scope of this monograph is indicated by the chapter titles: (1) Comparison of shock-wave methods and other techniques for investigating fast chemical reactions and other phenomena at high temperatures; (2) The hydrodynamic theory of shock-wave propagations in an ideal gas with constant specific heats; (3) Calculation of shock waves in real gases; (4) Theory of shock-wave structure; (5) The generation of shock waves in shock tubes; (6) Measurements of shock-wave parameters; (7) Investigation of chemical problems with shock waves. The authors have attempted to cover the literature in the field up to the summer of 1957.

Book is a valuable and, at present, unique contribution which belongs in the library of everyone interested either in shock waves or fast reactions. The discussion of the basic theory makes it of permanent value even though a survey of such a rapidly developing field can not avoid becoming rapidly dated. The available literature has probably doubled since 1957, and there is a backlog of material available only in reports of limited circulation.

The major recent trends have been the use of electrically driven shocks, an order of magnitude stronger than those considered in the book, for plasma research and the extensive use of shock tubes for hypersonic testing. While the latter is somewhat out of the field of interest of this book, and could be the subject of a comparable study, it has yielded data on such matters as the rate of oxygen dissociation and the radiative properties of air at high temperatures which are relevant. Current activity in the field of the monograph is indicated by the papers at the Eighth International Combustion Symposium in 1958.

It is strange that with the current American interest in translating foreign literature, a manuscript of this quality, originally written in English, should be available only in the German translation. The publishers deserve our gratitude, both for their enterprise and the quality of the printing. It is to be hoped that an English edition, with as much additional material as possible, will be available soon.

W. Squire, USA

824. Sternberg, J., Triple-shock-wave intersections, *Physics of Fluids* **2,** 2, 179–206, Mar.–Apr. 1959.

This paper deals with the shock geometry at the triple point of a Mach reflection. The case of weak shock waves is discussed in particular and the results of some experimental work employing an electric analogy tank are included. Author concludes that the solutions at the triple point as given by von Neumann and Guderley are invalid for weak shocks.

Results from the electric analog study show that the shock waves are so strongly curved at the triple point that angles cannot

be measured in the laboratory unless perhaps the dimensions of the shock tube are greatly increased.

A semi-quantitative description is given of a real fluid (viscous) model which, according to the author, is consistent with experimental data and with the Navier-Stokes equations.

E. K. Parks, USA

825. Grigorian, S. S., On the motion of a slender solid body under the effect of a strong shockwave (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 165–166, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. G-162,2 pp.)

The problem is formulated by neglecting small perturbation behind the strong shock wave due to entry of the body. An integral equation governing the motion of the body is formulated and solved by an iterative successive approximation. Convergence proof of the method is also given. W.-H. Chu, USA

826. Kogan, A., On two-dimensional shock-waves for near-detachment flow, *Bull. Res. Counc. Israel* **7F,** (Math. and Phys.), 3, 123–128, Nov. 1958.

Von Mises transformation is applied to compressible rotational stream function equation. By using results of previous analysis [*Quart. J. Mech. Appl. Math.* **11**, no. 1, 1958; AMR **11** (1958), Rev. 4624] author proves that for title problem one term in equation is negligible when free-stream Mach number is greater than about 3. Upon neglecting this term equation reduces to ordinary differential equation which author readily integrates. Using this result author presents closed analytic expressions for pressure and temperature along airfoil in terms of quantities along shock. The symbol ν is used both for velocity component and shock angle; some symbols are undefined; Fig. 1 is printed upside down.

T. R. Goodman, USA

827. Korobeinikov, V. P., and Riasonov, E. V., Construction of exact discontinuous solutions of the equations of one-dimensional gas dynamics and their applications, *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 2, 362–367, 1958. (Reprint order no. PMM 32, Pergamon Press, 122 E. 55th St., New York 22, New York.)

Authors investigate the problem of the propagation of plane, cylindrical, and spherical shock waves in a perfect gas. They employ the particular class of appropriate gasdynamic solutions given by Sedov [*Doklady Akad. Nauk SSSR* **90**, p. 735, 1953]. In general, these solutions represent nonisentropic flows. They contain one arbitrary undetermined function which must be found in order to construct a solution with a shock wave present.

Authors develop a method to determine this arbitrary function in the case when a shock wave is propagated through a gas which has a constant pressure, is at rest, but whose density is a function of the distance from the center of symmetry of the wave. Their determination of the arbitrary function involves the solution of a Riccati-type equation which cannot be gotten in closed form for arbitrary specific heat ratios. The authors, therefore, restrict themselves to several special cases, for which the physical situation is not always clear to this reviewer, and for these cases determine the shock-wave motion and conditions behind the shock. Using energy considerations they show how non-self-similar problems of a point blast in a gas whose initial density is variable may be solved with their solutions. In the particular case of a strong shock it is shown how the solution reduces to the more familiar self-similar case. It is also pointed out how these solutions can be applied to corresponding unsteady piston problems.

R. F. Probstein, USA

828. Murthy, S. N. B., On some one-dimensional expansion processes with shock waves, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 235–242.

"A number of expansion and explosion processes capable of being treated in one-dimensional spherical or Cartesian co-ordinates are discussed analytically. If the expansion is into a vacuum the problem can be treated fully analytically. When there is an initial density distribution in the direction of expansion, some particular cases are solvable in the same way."

Reviewer found paper rather difficult to follow owing to frequent misprints and obscurities. Reference is made to papers by J. M. Burgers (1946) and G. C. McVitte (1953, 1956) with applications to to interstellar gas clouds and cosmology.

A. H. Armstrong, England

829. Devienne, F. M., On similitude in rarefied-gas aerothermodynamics, *J. Aero/Space Sci.* **26**, 3, 183–184 (Readers' Forum), Mar. 1959.

830. Harris, E. L., Investigation of free-molecule and transition flows near the leading edge of a flat plate, Univ. Toronto, Inst. Aerophys. Rep. 53, 70 pp., Nov. 1958.

Measured pressure distributions, as well as techniques for measuring pressures in low-density flows, are described. Free-molecule flow was found to exist within one mean-free-path length of the leading edge. An integral over impact pressures, analogous to the boundary-layer displacement thickness, was found to increase approximately linearly with distance in the free-stream direction. Reviewer believes that the descriptions of pressure probes (long-tube impact probe, short-tube impact probe, orifice impact probe, and static probe) included in this report are, in themselves, significant contributions. E. L. Knuth, USA

831. Toomre, A., Gas dynamics of free molecule flow, AFOSR TN 58-787 (Massachusetts Institute of Technology, Fluid Dynamic Research Group Rep. 58-2), v + 36 pp., Mar. 1958.

The influence of a solid object upon the velocity distribution of gas atoms in "free molecule flow" is studied in this report. A concept of "shadow flow" makes it possible to consider two distinct velocity categories, and in principle facilitates the calculation of the velocity distribution function at any point in space. The interaction with the surface is considered in detail. The cosine dependence of diffuse reflection, in particular, is shown to be useful. From author's summary

832. Kochina, N. N., and Mel'nikova, N. S., On the unsteady motion of gas driven outward by a piston, neglecting the counterpressure, *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 4, 622–631, 1958. (Pergamon Press, 122 E. 55th St., New York, N. Y.)

One-dimensional unsteady motion of a gas due to a piston with velocity $v \sim t^m$ (m = constant) is considered. The flow contains a shock whose velocity also varies as t^m. "Self-similar" flow patterns corresponding to different values of $m > -1$ and $\gamma > 1$ (γ = ratio of specific heats) are discussed. This range of m and γ is greater than that of previous papers.

H. Mirels, USA

833. Cabannes, H., One-dimensional unsteady flow of a compressible fluid (in French), *Rech. Aéro.* no. 59, 3–11, July-Aug. 1957.

I. Case of zero viscosity and thermal conductivity: Author treats rectilinear transient motion of a perfect gas with constant specific heats, replacing the independent variables x and t by new variables ψ and $\tau \cdot \psi$, called the "trajectory function," is defined by $d\psi = \rho dx - \rho u dt$. τ is just the time t.

The resulting equations are integrated to give closed-form solutions when (a) all fluid particles have the same entropy per unit mass and (b) $\beta = \frac{1}{2}\left(\frac{\gamma+1}{\gamma-1}\right)$ has an integral value. The simplest result appears when $\gamma = 3$, so that $\beta = 1$. A closed-form solution

is also discovered for a special law of dependence between specific entropy and trajectory function.

In preparation for Part II, author discusses a particular solution of C. W. Jones [*Proc. Roy. Soc. Lond.* (*A*) **228**, p. 82, 1954] which is related to the propagation of shock waves into a medium of continually decreasing density.

II. Case of a viscous, heat-conducting fluid: Author assumes Navier-Stokes equations, zero bulk viscosity, constant shear viscosity, thermal conductivity and specific heats.

First setting heat conduction equal to zero, author introduces the trajectory function in a slightly modified way, i.e., by $\varepsilon d\psi = pdx - \rho udt$, with ε a constant. Then solutions are proposed in the form of power series in ε. What the physical significance or convergence of these series is is not discussed, and is certainly not clear to the reviewer.

Finally, the modification of Jones' analysis to account for viscosity and heat conduction is discussed. The solution in absence of these effects is recovered by letting a parameter, which is mean molecular collision time divided by characteristic macroscopic flow time, vanish. Another solution is formally obtained when this parameter goes to infinity! Again, no discussion of physical meaning is given. F. S. Sherman, USA

834. Krasil'shchikova, E. A., Wing of finite span with a symmetrical profile in compressible flow, *Soviet Phys.-Doklady* **3**, 3, 475–478, Jan. 1959. (Translation of *Doklady Akad. Nauk SSSR* (*N. S.*) **120**, 1, 51–54, May–June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The problem of rectilinear and generally unsteady motion of a thin symmetrical wing with arbitrarily given planform at zero incidence is formulated with reference to a coordinate system fixed in space, so that the linearized differential equation for the potential is, both for subsonic and supersonic speeds, the three-dimensional wave equation, solved by the retarded potential. Thus a very general class of motion leads, irrespective of whether it is subsonic or supersonic, toward the same form of solution, differing only by the respective regions of integration. This unified treatment is interesting. No special problems, however, are worked out and the possibly important transonic case is not entered into.

A. Von Baranoff, France

Boundary Layer

(See also Revs. 804, 874, 888, 893, 898, 899, 904, 914, 916)

835. Rozin, L. A., The growth of a laminar boundary layer on a flat plate set impulsively into motion, *Appl. Math. Mech.* (*Prikl. Matb. Mekb.*) **22**, 3, 568–575, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Paper deals with a problem of fundamental importance in unsteady viscous flow theory, namely, the investigation into the singular behavior of the solution to the boundary-layer equations for the case of the growth of boundary layer on a semi-infinite plate set suddenly into motion. As was first pointed out by K. Stewartson [AMR **5**(1952), Rev. 487], the inadequacy of the solution to the boundary-layer equations within the framework of perturbation with respect to the time variable t manifests itself conspicuously in that the initial approximate solution so obtained depends solely on the variables y (normal to plate) and t, and that the higher-order perturbations vanish then identically. Stewartson and later Cheng [AMR **10** (1957), Rev. 2605], operating with the boundary-layer equations, failed to provide any concrete clue to the discrepancy between the mathematical solution and the expectation based on physical considerations. In this respect, the present author is to be commended for his attempt in working with the full Navier-Stokes equations. However, it should be seriously questioned whether the author can be justified in his postulation [Eq. 2.4 in his paper], which involves an assumption regarding the pressure gradient. Reviewers believe that the author's essential contribution amounts to the solution of another approximate equation to the Navier-Stokes equations, thus elucidating more clearly than the previous investigators the inadequacy of the boundary-layer equations in the treatment of unsteady viscous flows with the usual perturbation procedure.

H. Gortler and E. Y.-C. Sun, Germany

836. Dorfman, A. Sh., and Pol'skii, N. I., and Romanenko, P. N., Self-similar solutions of the laminar boundary layer equations for a compressible fluid including heat transfer, *Appl. Math. Mech.* (*Prikl. Math. Mekb.*) **22**, 2, 375–382, 1958. (Reprint order no. PMM 34, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Authors apply a modified Howarth-Dorodnitsyn transformation to the two-dimensional compressible boundary-layer equations, and for the case of constant Prandtl number and a constant product of the density and viscosity investigate the mathematical criteria for the existence of self-similar solutions. By a self-similar solution is meant that the boundary-layer equations are reducible to ordinary differential equations. It is shown that for Prandtl number not equal to one, the conditions for similarity are that the external velocity and surface temperature be constant. For a Prandtl number equal to one it is shown that similar solutions exist for a constant external velocity with a power-law variation of the surface temperature in terms of a modified x-dependent variable. In this case similar solutions are also shown to exist for a constant surface temperature with a power law or exponential variation of the free-stream velocity. A discussion of the criteria for similar boundary-layer solutions including axial symmetry and variable fluid properties may be found in "Hypersonic flow theory" by W. D. Hayes and R. F. Probstein, Academic Press, N. Y., 1959, and in the references cited therein. R. F. Probstein, USA

837. Fediaevskii, K. K., and Nastiukova, G. K., Cylindrical body with an intense crisis of drag, *Soviet Phys.-Tech. Phys.* **3**, 7, 1435–1439, July 1958. (Translation of *Zh. Tekh. Phys., Akad. Nauk SSSR* **28**, 7, 1556–1561, July 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

These investigations have proven the existence of cylindrical bodies with a somewhat more intense crisis of drag than that occurring in the case of a circular cylinder. In the case of the cylindrical body investigated the crisis effects a radical change in the picture of pressure distribution, while the drag coefficient falls to about a fifth. This permits the conclusion that in the case of the cylindrical body investigated, the breakaway of the laminar boundary layer takes place near the thickest part, while in the case of a turbulent boundary layer no breakaway actually takes place. From authors' summary

838. Konovalov, I. M., The theory of the turbulent boundary layer and its use in hydraulic engineering and shipbuilding (in Russian), *Recb. Transport* no. 11, 11–13, 1956; *Ref. Zh. Mekb.* no. 7, 1958, Rev. 7757.

An approximate theory is developed for the boundary layer as applied to nonuniform flows in open channels. Author defines the loss of head as a change in quantity of motion, and arrives at the following Eq. [5] for the tangential stress:

$$\tau = \frac{\rho n \lambda a_0}{2 q_0} \frac{\partial V^2}{\partial n} \qquad [5]$$

where ρ is the density, q_0 is the constant flow along the line of flow, a_0 is the rate of transfer, determined from the equation $a_0 = dq/ds$, and λ is a quantity, similar to the mixing length, determining the change in the velocity V along the normal n. The arbitrary conclusion is drawn from this equation that the multiple

in the derivative must depend solely on n, i.e.

$$\tau = \rho f(n) \frac{dV^2}{dn}$$

Assuming further that $f(n) = C$ = constant, author obtains an elliptical form for the velocities which, in his opinion, "corresponds well with the experimental values." This conclusion contradicts both the physical features of the phenomenon and numerous experimental data.

Author continues by stating the hypothesis, contradictory to the foregoing, that "τ may with sufficient approximation be considered independent of the transverse coordinates," i.e.

$$\tau = -\rho f(s) \frac{dV^2}{dn} \qquad [2]$$

Transferring to rectilinear coordinates, and assuming

$$f(x) = a^2 x \qquad (a^2 = \text{const}) \qquad [3]$$

the author obtains the final equation

$$\tau = -\rho a^2 x \frac{dV^2}{dn} \qquad [4]$$

(in the article, Eq. [3] also erroneously contains g, the acceleration due to gravity). Thus, if the somewhat artificial and contradictory conclusion is discarded, author concludes that the coefficient of turbulent exchange is proportional to the mean velocity, and, for nonuniform flow, to the longitudinal coordinate. We know that the hypothesis that the coefficient of turbulent transfers is proportional to the longitudinal velocity is contradictory to the experimental data. Using Eq. [4] author obtains the equation for specific energy

$$\bar{e} = V^2/2g + p/\gamma$$

in the form

$$\frac{\partial \bar{e}}{\partial (x^2)} = a^2 \frac{\partial^2 \bar{e}}{\partial y^2} \qquad [5]$$

The fields of velocities in the boundary layer during flow past a plane body and in a turbulent jet are determined using this equation. In the first case a constant a is adopted which is proportional to the coefficient of resistance of the plate, which depends on the Reynolds number. It is pointed out that the theory outlined has been used to calculate the break away points in flow past a cylinder, the results coinciding well with those of experiments. The latter assertion must be verified by multiple, not single, tests.

E. M. Minskii

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839. Whitfield, J. D., and Potter, J. L., The role of unit Reynolds number in boundary-layer transition, *J. Aero/Space Sci.* **26,** 3, 186–187 (Readers' Forum), Mar. 1959.

Authors maintain that transition Reynolds number may vary with the dimensional parameter, Reynolds number per unit length, even after accounting for the fact that variation in Reynolds number per unit length causes variation in roughness Reynolds number, leading-edge-bluntness Reynolds number, etc. To demonstrate this, they consider two conditions on a flat plate in incompressible flow, and derive under these two conditions, for equal ratios of Reynolds stress to laminar shear stress (a measure of closeness to transition), a relation between displacement thickness Reynolds numbers and nondimensional energies at the frequencies for maximum amplification. Authors then state that experiments show that critical frequency increases with increasing Reynolds number per unit length, and use this result to reach conclusion given above. Reviewer points out that if such "pure" Reynolds-number-per-unit-length effects occur, they must mean that at least one other nondimensional parameter, hitherto unaccounted for, has come into play; e.g., another length (say, scale of free-stream turbulence) resulting in another Reynolds number.

I. Greber, USA

840. Kuo, Y. H., Dissociation effects in hypersonic viscous flows, *J. Aero. Sci.* **24,** 5, 345–350, May 1957.

The thermodynamics and chemical equilibrium of a simple dissociating gas are discussed briefly. The boundary-layer equations are presented for a two-dimensional steady flow of a diatomic gas past a fixed semi-infinite plate. The general equations for the conservation of mass (for each component) and momentum appear to be correct. [The momentum loss in both the dissociating and diffuse recombination is assumed to be negligibly small as are the effects of thermal diffusion.] In the energy equation [4.3] the dissociating energy is neglected. In the development of the analysis the energy equation is written completely in terms of the enthalpy [Eq. 4.6].

The results of this analysis indicate that the flow of a dissociating boundary layer is quite similar to the well-known boundary layers if certain dimensionless parameters are interpreted in a more general way.

In the opinion of the reviewer, the general energy equation [Eq. 4.6] is incomplete because of several minor omissions:

(a) the dissociating energy is neglected in the energy equation;
(b) in the calculation of conducted enthalpy, author omits the fact that $dh = C_p dT + \sum_i h_i dC_i$; using just the first two terms of this relation;
(c) this difficulty also arises in the transformation of the diffusion gradient, i.e. the use of the derivative $\varepsilon_y = (\varepsilon_H)(H_y)$ is preferable to $\varepsilon_y = (\varepsilon_T)(H_y)/C_p$

The omission (b) can be corrected by replacing the Lewis number by the Lewis number minus one wherever it occurs. The omission (c) can be corrected by dividing ε_T/C_p by $(1 + H_A - H_{A_2})$ wherever it occurs.

If these changes are included in the definitions of the parameters in which Professor Kuo presents his results, then his general conclusions are unaltered, if the heat-transfer rates are not too large.

E. E. Covert, USA

841. Zigrang, D. J., Note on "Dissociation effects in hypersonic viscous flow," *J. Aero. Sci.* **24,** 12, 916–917 (Readers' Forum), Dec. 1957.

The purpose of this note is to discuss the approximation concerning the Prandtl number in an article by Professor Kuo [see preceding review]. The principal question is whether the definition of the thermal conductivity includes or does not include the enthalpy difference between diffusing components in gas in thermal equilibrium. The suggestion that the energy transported by the diffusion of components of different basic enthalpies be included in the thermal conductivities does, in some case, simplify the calculation. However, the definition of thermal conductivity does not include this additional term. Professor Kuo's definition and use of the Prandtl number is correct.

E. E. Covert, USA

842. Yang, K.-T., Unsteady laminar boundary layers in an incompressible stagnation flow, *J. Appl. Mech.* **25,** 4, 421–427, Dec. 1958.

Characteristics of the unsteady incompressible laminar boundary layer near the stagnation point of a blunt heated two-dimensional body are presented. An exact solution of momentum, continuity, and energy equations is obtained when the free-stream velocity is inversely proportional to a linear function of time. Particular

function chosen is $(1 - \alpha t^*)$ where t^* is dimensionless time and α is a constant. Dimensionless velocity and temperature profiles, corresponding wall gradients, etc. are plotted and tabulated as functions of α.

Based on this exact solution author develops an approximate method for arbitrary cylinder velocity variations. Method is illustrated by considering impulsive cylinder motion, periodic cylinder motion, constant acceleration or deceleration, and a linear acceleration change. Good agreement with other solutions is demonstrated. Comparison with quasi-steady solutions indicates superiority of present method for large accelerations and times.

At zero time, approximate method yields unlimited value of α for flow starting from rest with an arbitrary acceleration. Author suggests starting solution using quasi-steady approximation in this case. H. E. Brandmaier, USA

843. Gvozdkov, N. N., Transient motion of a viscous liquid in a boundary layer (in Russian), *Trudĭ In-ta Matem. i Mekh., Akad. Nauk UzSSR* no. 15, 99–105, 1955; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6746.

A method is proposed for the solution of the problem of the nonstationary boundary layer, the method consisting in the replacement of a wall, in whose vicinity the boundary layer appears, by a distribution of vortices, which, by scattering, spread over the region occupied by the moving liquid. The velocity field is built up by this distribution of vortices and it is proposed to treat it as the field of the boundary layer. The intensivity of the vortices' distribution on the wall has to be found from the condition of adhesion to the wall, which leads to the integral equation. The problem for the plane plate is solved. It should be noted that the linearization of the equation of transposition of the vortices, carried out by the author, is not correct in the vicinity of the profile being flown around, if the velocity of the latter is other than small; consequently the method proposed by the author is not suitable for the solution of problems relating to boundary layers, which are, in essence, nonlinear. In addition, author has committed some errors. To enumerate: first, the reasons are not clear for the proposed constancy of the equation for the transfer of the vortices in transition from the immovable system of coordinates to the movable. Secondly, the fields of vortices and of the velocities constructed by the author do not satisfy the necessary boundary conditions, because the field of velocities is discontinuous on axis $y = 0$, though it is symmetrical relative to this axis.

S. S. Grigoryan

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844. Furuya, Y., Experiments and theory on flow in the diffuser, *Mem. Fac. Engng., Univ. Nagoya* **10**, 1, 1–41, May 1958.

Description of experiments on turbulent boundary layer on flat plate with pressure gradient is followed by formulation of empirical method of calculation based on results of other workers. Method involves integration of two ordinary differential equations and results compare well with Clauser [AMR **7**(1954), Rev. 3654], but comparisons with author's own experiments are not given.

Divergence of stream lines and secondary flows that occur in rectangular diffusers are then briefly considered. Finally, good agreement between theory and experiment for separation in 20° conical diffuser is shown. Reviewer notes that paper consists of four previous papers published in Japanese. Little attempt at integration has been made. D. G. Hurley, Australia

Turbulence

(See Revs. 839, 919, 927, 928, 938, 1018, 1021)

Aerodynamics

(See also Revs. 613, 800, 801, 802, 803, 805, 811, 814, 816, 822, 834, 839, 872, 873, 879, 895, 915, 939, 963, 970)

Book—845. Handbook of supersonic aerodynamics, Vol. 3, (Bureau of Ordnance Publication, NAVORD Rep. 1488-Section 7), Washington 25, D. C., Superintendent of Documents, U. S. Government Printing Office, 1957, 74 pp. $1.50.

This section of the Handbook presents the aerodynamic characteristics of a limited class of finite wings in a convenient form for use in design calculations. Theoretical airfoil characteristics for lift, pitching moment, and pressure drag are computed by the method of supersonic source distributions. They are presented in graphical form using nondimensional parameters. Sample calculations and a brief comparison of theory and experiment are included. From the summary by A. Petroff, USA

846. Clarke, J. H., On the application of the Ursell-Ward theorem to wings with edge forces, *J. Aero/Space Sci.* **26**, 535–536 (Readers' Forum), Aug. 1959.

In much of the recent work on drag minimization for supersonic airplanes, use is made of the Ursell-Ward theorem concerning flow reversal. In some cases the class of wings considered excludes those with edge singularities. The subject note clarifies the effect of edge singularities on the drag reversal relations, and corrects a recent erroneous claim that the constant combined downwash criterion of Jones does not apply when edge forces are acting. F. B. Fuller, USA

847. Scherer, M., and Walden, S., Comparison of some methods for the study of lateral stability in the specific case of a glider with delta wings (in French), *Rech. Aéro.* no. 62, 7–13, Jan.–Feb. 1958.

848. Lee, G. H., Note on the flow around delta wings with sharp leading edges, *Aero. Res. Counc. Lond. Rep. Mem.* 3070, 22 pp., 1958.

849. Sirazetdinov, T. K., A wing of finite span at large angles of attack (in Russian), *Trudĭ Kazansk. Aviats. In-ta* **31**, 65–83, 1956; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7478.

A method is given for calculating the circulation and certain other characteristics of straight and sweptback wings at critical and supercritical angles of attack. The author uses the results of his previous work [*Trudĭ Kazansk. Aviats. In-ta* **31**, 51-64, 1956], in which he gave a wing vortex diagram, a means of calculating the angles of downwash of the flow and the true angles of attack at points on the center line, and also a linking equation reducing the characteristics of the cross section of a wing of finite span to those of side-slipping, infinitely long wings. In the case in point, these results are applied for large angles of attack, and a nonlinear integro-differential equation is obtained for the circulation. This equation is solved by the successive approximations method. It is recommended that a zero approximation for the circulation be obtained by assuming the angles of downwash of the flow to be zero. This value for the circulation is then used for obtaining the zero approximation for the angles of downwash. Here the author neither remarks on nor allows for the circumstances that at the wing tips infinitely large angles of downwash will be obtained in the end chord. In order to obtain all the subsequent approximations, the equation is linearized. Thus, to obtain the $(n + 1)^{th}$ approximation, the actual angles of downwash $\Delta\alpha$ are represented by the sum $\Delta\alpha = \Delta\alpha^{(n)} + \delta\alpha$, where $\Delta\alpha^{(n)}$ is the n-th approximation and $\delta\alpha$ a small additional downwash angle. After this, the basic equation is linearized according to the angle $\delta\alpha$ and put into a form similar to the Prandtl equation for a

straight supporting line. The convergence of the process of successive approximations is not investigated, but it is asserted that only a first approximation will be necessary in practice. The whole sequence of calculation of the circulation at large angles of attack is only illustrated in detail for straight wings. An approximate equation is deduced for a sweptback wing of uniform section; this equation enables a curve to be plotted comparatively easily for the lift coefficient for this wing at all angles of attack, provided that the analogous relationship for a straight wing with the same expansion and contraction values, and the same Reynolds number, is known. Calculation of the angle of attack required to initiate auto-rotation of a wing is also examined. For this purpose the basic equation for the circulation of a wing rotating uniformly around a longitudinal axis is linearized in a manner similar to that in the previous case. This enables a separate linear equation to be written for the additional circulation caused by the rotation. As usual, the effect of the rotation is allowed for by the equivalent twisting of the wing along its span. The angle of attack as the wing commences auto-rotation is determined from the condition that the banking momentum coefficient for the rotating wing is equal to zero. The results of certain calculations are compared with experimental data.

G. F. Burago

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850. Kadyrov, S., Motion of finite span wings with supersonic speed (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 35–40, Aug. 1957.

Author considers briefly the problem of supersonic flow behind a shock wave attached to the leading edge of a finite wing and outlines a method of solution based on the well-known artifice of expanding the flow variables as power series in the space variables and their products, assuming the wing surface to be specified by a similar series. Reference is also made to similar method of solution for flow between (1) wing surface and characteristic surface, (2) characteristic and shock, and (3) two characteristics.

Reviewer believes the paper is of little practical use since principles of the method are well known and no solutions for various series coefficients are given.

H. K. Zienkiewicz, England

851. Relf, E. F., Note on the lift slope, and some other properties, of delta and swept back wings, *Aero. Res. Counc. Lond. Rep. Mem.* 3111, 9 pp., 1959.

852. Hobbs, N. P., The transient downwash resulting from the encounter of an airfoil with a moving gust field, *J. Aero. Sci.* **24,** 10, 731–740, 754, Oct. 1957.

853. Cole, J. D., and Royce, W. W., An approximated theory for the pressure distribution and wave drag of bodies of revolution at Mach number one, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 254-276.

Authors show how the nonlinear small-disturbance equation can be approximated by a linear equation which can be solved, and whose solutions retain sufficient accuracy in the prediction of surface pressures to be a useful engineering approximation.

R. C. Binder, USA

854. Tan, H. S., Nose drag in free-molecule flow and its minimization, *J. Aero/Space Sci.* **26,** 6, 360–366, June 1959.

Author first derives the expression for the drag of a body of revolution of length l in axisymmetric free-molecule flow. Minimizing this drag turns out to be a special Bolza problem in the calculus of variations. This problem he then solves for the two extreme cases of very small speed ratio S (subsonic flow) and for large S (hypersonic flow).

The results indicate in both cases that for minimum drag the nose must have a flat tip. The subsonic case optimim shape also depends upon the temperature ratio while the hypersonic shape does not. Several optimum shapes are plotted for different temperature ratios.

R. E. Street, USA

855. Jones, R. T., The Kutta condition and the condition for minimum drag, *J. Aero/Space Sci.* **26,** 6, 382–383 (Readers' Forum), June 1959.

856. Strike, W. T., and Whitfield, J. D., Forebody drag characteristics of an ogive cylinder, *J. Aero/Space Sci.* **26,** 6, 383–384 (Readers' Forum), June 1959.

857. Lehnigk, S., Theorem on stability criteria in flight mechanics (in German), *Z. Flugwiss.* **6,** 4, 110–115, Apr. 1958.

In linear stability problems of flight mechanics, characteristic polynomials frequently occur with coefficients depending on variable parameters. Of particular interest is the case of a characteristic polynomial structurally given as the sum of two polynomials. The problem is whether it is possible in such a case to stabilize a dynamically unstable flight condition only by choosing suitable moduli of the parameters. A theorem for the existence of stability areas is formulated for a special type of structurally given polynomials. The significance of the theorem and its application are illustrated by two examples of flight mechanics.

From author's summary by A. D. Young, England

858. Czaykowski, T., Definitions of damping in aircraft response, *Aircr. Engng.* **30,** 354, 227–232, Aug. 1958.

859. Friedlander, S. K., Particle impaction on spheres at high Mach numbers, *ARS J.* **29,** 4, 296–298 (Tech. Notes), Apr. 1959.

Author uses Stokes's law to simplify equations of motion and finds that a sphere of 1-ft radius travelling at 8000 fps at 36,000 ft should not intercept particles smaller than 5-microns diameter, unit density. Since actual drag coefficient over most of the trajectory exceeds Stokes's value, limiting diameter should be somewhat larger. Those having need to compute more accurate data should refer to extensive literature on aircraft ice prevention reviewed by University of Michigan or by AGARD, particularly with respect to machine computation techniques.

M. Tribus, USA

860. Roy, M., Means and examples of aeronautical research in France at ONERA (Twenty-second Wright brothers lecture), *J. Aero/Space Sci.* **26,** 4, 193–206, Apr. 1959.

Vibration and Wave Motion in Fluids

(See also Revs. 962, 965, 987, 990, 991, 1012)

861. Yamada, H., Permanent gravity waves on water of uniform depth, *Rep. Res. Inst. Appl. Mech. Kyushu Univ.* **6,** 23, 127–139, 1958.

Author investigates gravity waves of finite size and permanent form for the case of finite, uniform depth of fluid, employing conformal transformation techniques applicable to irrotational waves. The work is a generalization of earlier work by the author concern-

ing the highest deep water waves and solitary waves. The method of computation, which employs the Jacobian elliptic function, has certain advantages relative to the systems employed in the work of Michell [*Phil. Mag.* **36**, 1893] and Havelock [*Proc. Roy. Soc.* (A) **95**, 1919].

As an example, author evaluates the highest permanent wave for the modulus $k = \sin 80^\circ$ ($k = 0$ corresponds to infinite depth, $k = 1$ to solitary waves). His results may be compared with those of Chappelear [Beach Erosion Board, Tech. Memo no. 116, 1959] who employed a different method of computation for the highest waves in water of limited depth:

	D/L	H/L	$\frac{2\pi C^2}{gL}$
Chappelear	.2638	.1303	1.1176
	.2314	.1246	1.0792
Yamada	.2597	.12775	1.1025

Here D is the still water depth, L wavelength, H wave height, C celerity, and g gravity. If we interpolate Chappelear's values on D/L we find that his values of relative height and celerity are slightly higher than those of Yamada. However, both systems of calculation give good agreement for the highest waves in deep water.

R. O. Reid, USA

862. Khaskind, M. D., Diffraction of propagated waves around a vertical barrier in a heavy fluid (in Russian), *Izv. Akad Nauk SSSR, Otd. Tekh. Nauk* no. 8, 146–149, Aug. 1957.

A method is presented which permits determination of perturbed forces and moments produced by waves about a barrier extending from bottom to surface. It is shown that the moments and forces are completely determined by the asymptotic character of the radiation function characterizing the radiated waves due to the vibrations of the deformed barrier. Derived equations are applied to concrete cases. A method is indicated for approximate computation of asymptotic characteristics of radiation function for an arbitrarily shaped vertical cross section of the barrier.

From author's summary by D. Boyanovitch, USA

863. Debye, P., and Daen, J., Stability considerations on non-viscous jets exhibiting surface or body tension, *Physics of Fluids* **2**, 4, 416–421, July-Aug. 1959.

The question of the range of ejected liquid streams is connected with the relation of the stability of the jet motion to an initial infinitesimal disturbance. This is investigated as a theoretical problem for the planar and cylindrical cases neglecting any fluid viscosity. In addition, the stabilizing influence of either a surface or "body tension" is calculated. Comparison of the theory with some published data is found to yield qualitative and semiquantitative agreement. The possibility of applying this theory to the measurement of dynamic tensions is suggested.

From authors' summary by K. Schneider, USA

Fluid Machinery

(See also Revs. 574, 644, 673, 844)

864. Ichikawa, T., Characteristics of internal gear pump, *Bull. JSME* **2**, 5, 35–38, Feb. 1959.

Author calculated the ideal delivery, its pulsation factor and the variation of trapped volume of an involute internal gear pump. The characteristics were verified by experiments. In contrast to the conventional external gear pump there are the following advantages: (1) pulsations of the delivery and delivery pressure are small; (2) variation of the trapped volume is small; (3) no pressure rise or decrease in this space with no relief groove.

From author's summary by N. Scholz, Germany

865. Nickel, K., A special case of horizontal airfoils in arbitrary nonstationary movements (in German), *Ing. Arch.* **25**, 2, 134–139, 1957.

Author extends his previous work [AMR **9** (1956), Rev. 3025] on nonstationary flow past a cascade of airfoils with parallel chord lines of finite length l and spacing t. In the present paper, the undisturbed flow is parallel to the chord length which is assumed to extend to infinity in the upstream direction. The results obtained can be applied to the case of finite l in the initial stage of motion. A particular case when the profile is replaced by a semi-infinite plate with a flap at the trailing edge has been worked out and closed solutions are given.

S. D. Nigam, India

866. Kochkarev, A. Ya., Characteristics of a stream in the meridial cross section of a hydromuff with radial blades (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 187, 54–57, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 646.

An axisymmetrical flow of the noncompressible fluid is examined in a hydro-muff with radial blades. Author assumes that flow of the streams divides the inner hollow of the muff into separate zones. Flow of the liquid through each zone is found from the energy equation

$$H_{tn} + H_{tm} + \Sigma h = 0$$

where the works H_{tn} and H_{tm} are determined by the changes in the momentum of the quantity of the moving liquid in the pump and the turbine respectively; in the sum of the hydraulic losses Σh, the losses are taken as proportional to the square of speed (or to Q^2) and the "shock" losses which are proportional to the square of the difference of circular speeds of the pump and turbine.

Calculated distribution is presented of the nondimensional meridial radial component of speed which was evidently obtained from the equation of continuity.

The obtained speed distribution depends essentially on the means by which the stream is led and does not conform to the Euler equation projected on the radius (the so-called equation of radial equilibrium) which the author does not use.

G. Yu. Stepanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

867. Forman, G. W., and Kelly, N. W., Cooling tower fan performance, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-17, 5 pp.

A simple method of predicting the performance of cooling tower fans has been presented and compared by example with results of both model and full-scale tests. The method may be used to advantage by purchasers of cooling tower fans to determine the validity of performance data presented by prospective suppliers of cooling tower fans. Although the calculated horsepower may be in error by as much as 20%, the predicted air flow will be within approximately 6% (the cube root of 1.2), which is within field test accuracy. Manufacturers of cooling towers and cooling tower fans have, over the years, indicated accuracies of fan performance and horsepower prediction that are inconsistent within the state of knowledge of the art.

From authors' summary

868. Hori, C., and Kawaguchi, K., Cavitation tests on an axial flow pump, *Bull. JSME* **2**, 5, 187–195, Feb. 1959.

Cavitation tests on an axial flow pump were made over a wide range of operating conditions. Through these tests, the aspects of cavitation in the impeller were observed with a strobolight, and variation of the pump characteristics was studied. A parameter σ_s to represent the suction condition was introduced to give the cavitation limits for any flow rate.

The pump head showed little change until the cavitation on the blade surface was developed considerably, while the shaft horse-

power began to increase slightly with the incipient cavitation on the blade, decreasing abruptly as the pump head dropped due to the growth of cavitation. So the efficiency showed gradual decrease as the incipient cavitation grew.

The cavitation limits concerning the incipience on the blade and variation in pump performance are presented against the flow rate in terms of the parameter σ_s as well as in the suction specific speed. From authors' summary

869. Gaigerov, V. I., The influence of the properties of a working medium on the characteristics of the centrifugal compressor or gas turbine (in Russian), Trudi N.-i. Labor. Dvigatelei M-va Transp. Mashinostronie SSSR no. 4, 109 pp. + illus., 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7574.

Research is carried out into the relationship between the basic parameters characterizing the work of centrifugal compressors and gas turbines (specific capacity, ratio between input and output pressures, efficiency) and the properties of the working medium; this research is principally from the point of view of modelling the work of hydraulic machines by using heavy gases. Ignoring the influence of the Prandtl number, and assuming that within the limits investigated the working conditions do not depend on the Reynolds number, author represents the generalized characteristics for a compressor (also for a turbine) of specific geometrical configuration in the form

$$f\left(\frac{nD_2}{\sqrt{RT_{01}}}, \frac{G\sqrt{RT_{01}}}{p_{01}D_2^2}, k\right)$$

where n is the number of revolutions, G is the gravimetric consumption, R the gas constant, k the adiabatic factor, p_{01} the retarding pressure at the input, T_{01} the input retarding temperature, and D_2 the external diameter. The procedure and results of experimental research carried out with four different gases, mainly to explain the influence of the adiabatic factor on the shape of the characteristic, are set forth. For the form of similarity criteria selected, this influence proves to be substantial in the case of compressors and appreciable in turbines. It is pointed out that it is more convenient to make comparisons for different values of k by plotting the characteristic for a compressor with relation to the consumption coefficient determined from the parameters on force feed, and that for a turbine with relation to the power factor. The possibility of using the given consumption and circumferential velocity as the criteria is noted, but the relevant research was not carried out. No clearly described research was carried out into the influence of the Mach number. An approximate method for converting compressor or turbine characteristics from one adiabatic factor to another is proposed. N. A. Kolokol'tsov

Courtesy Referativnyi Zhumal, USSR
Translation, courtesy Ministry of Supply, England

870. Nakamura, K., Sawada, T., and Kamei, T., Researches on axial flow turbines, 1st Report, *Bull. JSME* **2,** 5, 182–187, Feb. 1959.

It is necessary to carry out actual turbine testings to know the characteristics of turbine blades in the moving state. Authors study the dynamical characteristics of turbine blades with two testing turbines; one is an impulse turbine of partial admission and the other is a specially designed low-pressure turbine of double rotation type.

Reported here are the results which have been obtained with the former. Authors measured the torque and thrust of turbine shaft, and calculated the magnitude and direction of exit velocity from blades. On the other hand, the outlet flow angle and velocity were measured by yawmeter and pitot tube. Comparing these two methods, the first method was more simple than the second and there was a good agreement between both results.

From authors' summary

871. Coward, K. S., Propeller static thrust, *Aero/Space Engng.* **18,** 3, 64–68, Mar. 1959.

Static thrust becomes highly important when a propeller is to be used to provide it, and thus the lift for a vertical take-off type of aircraft. Present test data, however, are meager, and extensive experimental investigation is necessary.

From author's summary

872. van der Elst, W. J., Design theory for ducted-fan flying platforms, *So. African Mech. Engr.* **8,** 7, 207–223, Feb. 1959.

A theory is presented for the design of a ducted-fan type of "flying platform" or VTOL aircraft. The particular case of a hovering craft having contra-rotating rotors is considered. The theory introduces some empirical loss coefficients that require further investigation, but it does indicate a rational approach for further development. From author's summary

873. Heyson, H. H., Induced flow near a helicopter rotor—a review of present knowledge, *Aircr. Engng.* **31,** 360, 40–44, Feb. 1959.

Flow and Flight Test Techniques and Measurements

(See also Revs. 805, 819, 922, 933, 970, 971, 986)

874. Leadon, B. M., and Bartle, E. R., On the measurement of local skin friction by means of a surface probe in the case of low speed turbulent flow over a porous flat plate with mass injection, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 350–361.

The work of previous investigators on Preston-type surface probes for turbulent boundary layers is extended to case of porous wall with injection (of same fluid).

By calculating average pressure coefficients over open frontal area of tube, estimates are obtained for: (1) the effect of probe size and of ratio of inner to outer diameter; (2) effect of distortion of law of wall profile due to blowing. It is concluded that, for sufficiently large tubes, use of the law of the wall profile gives good results. Smaller probes should be raised above the surface a calculated distance to place them entirely within the logarithmic region.

Induced yaw (i.e. angle of attack) due to injection is estimated and shown to be negligible for a practical case.

A. Roshko, USA

875. Williams, T. J., Pulsation damping in pressure gauge connections, *Engineer, Lond.* **207,** 5380, 378–379, Mar. 1959.

In a previous paper, author examined the errors which may occur when a liquid manometer gage is used to indicate the time-mean of a pulsating pressure or pressure differential. The requirements for the elimination of these errors were determined, and a form of liquid manometer gage was proposed which would determine accurately the true time-mean of a pulsating pressure differential. This article is concerned with the same problem in relation to mechanical pressure gages, that is, gages which rely on the displacement produced in a mechanical part, such as a tube or diaphragm, when subjected to a difference in pressure. Examples of gages of this kind are the Bourdon gage, the Schaffer gage, and the low-pressure gages designed on the aneroid principle.

From author's summary

876. Al'tshul', A. D., The flow of liquids of considerable viscosity at varying levels and the theory of the Engler viscosimeter (in Russian), *Zh. Tekh. Fiz.* **27,** 4, 805–811, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7719.

It is proved that the equation which is adopted for calculating the time taken for a container to empty, when the liquid is flowing through an opening, gives good results in flow regimes where the coefficient of flow varies little. Where the Reynolds number is small during the flow of very viscous liquids, the value of the coefficient of flows is not constant, and the calculation therefore becomes incorrect. An equation is given for calculating the time taken for a container to empty with relation to the viscosity of the liquid; this equation is shown to give results which agree satisfactorily with experimental figures. With this equation as his basis, author makes the Engler viscosimeter theory more precise, and finds an analytical relationship between the Engler degrees and the kinematic coefficient of viscosity of the liquid. A graph is given to illustrate the good coincidence with the results of experiments. N. A. Zaks

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

877. Beecham, L. J., and Collins, S. J., Static and dynamic response of a design of differential pressure yawmeter at supersonic speeds, *Aero. Res. Counc. Lond. Curr. Pap.* 414, 55 pp., 1958.

Static calibration curves are provided for incidences up to 30° at speeds from $M = 1.3$ to 1.9, and the instrument is shown to resolve accurately when rolled out of the free-stream incidence plane. Relations are developed from which a close approximation to the Mach number, incidence and roll angle may be obtained, without recourse to calibration curves, in terms of the differential pressures across each pair of holes and the pitot pressure measured at an axial hole; the free-stream static pressure requires to be determined independently.

The dynamic behavior of the instrument and associated pressure pick-ups is examined, and a design developed for which the acoustic natural frequency is high compared with that likely to be encountered in flight. Certain inconsistencies have been observed between the characteristics as determined separately from the response to a pressure pulse in still air and that from an incidence cycle in a supersonic air stream, and it is suggested that these arise from changes in flow conditions within the tubes under lateral accelerations. From authors' summary

878. Matthews, D. L., Interferometric measurement in the shock tube of the dissociation rate of oxygen, *Physics of Fluids* **2,** 2, 170–178, Mar.–Apr. 1959.

A Mach-Zehnder interferometer was used to measure the dissociation rate of oxygen in a shock tube. Interferograms of a plane shock wave showed a reaction zone behind the shock wave in which dissociation was proceeding toward equilibrium. The width of this reaction zone varied with shock strength and reached dimensions as great as 1 cm. The principal reaction taking place behind and adjacent to the shock wave, and given by

$$O_2 + O_2 \underset{k_R}{\overset{k_D}{\rightleftharpoons}} 2O + O_2$$

was applied and values of k_D, the dissociation rate constant, and k_R, the recombination rate constant, were determined experimentally. The values of k_D were in good agreement with those of other investigators.

The paper includes a brief discussion of some of the existing dissociation theories of gases. E. K. Parks, USA

879. Alpher, R. A., and White, D. R., Optical refractivity of high-temperature gases, Part I: Effects resulting from dissociation of diatomic gases, Part II: Effects resulting from ionization of monatomic gases, *Physics of Fluids* **2,** 2, 153–169, Mar.–Apr. 1959.

Part I describes some studies of the optical index of refraction μ of dissociated diatomic gases. Interferometric measurements were made in a strong shock tube. The total refractivity was obtained for a partially dissociated gas. Since the density, degree of dissociation, specific refractivity of the molecular gas, etc., were known, calculation of the specific refractivity of the dissociated gas was possible.

Two gases, nitrogen and oxygen, were used in the experiments. It was found that the specific refractivity of atomic oxygen is slightly lower than molecular oxygen, while atomic nitrogen exhibits a specific refractivity significantly larger than that of the gas in the molecular state. Hence, authors conclude that in interferometric experiments employing air as the gas, the use of room-temperature specific refractivity should be terminated at temperatures causing appreciable dissociation of nitrogen.

Part II describes strong shock-tube interferometric studies of the index of refraction of shock-ionized argon. Applying plasma dispersion formula to refractivities measured on the interferograms, electron concentrations of 10^{17} per cubic centimeter were determined.

The mechanism of the ionization relaxation process visible on the interferograms is discussed. E. K. Parks, USA

880. Duff, R. E., Shock-tube performance at low initial pressure, *Physics of Fluids* **2,** 2, 207–216, Mar.–Apr. 1959.

An experimental study was made of the flow in a small diameter, $1\frac{1}{8}$-in. i d, shock tube operating at low initial pressures and small diaphragm pressure ratios. Because of the low densities involved, measurements were made with an electron beam densitometer. With the initial pressure at 1 mm of Hg and a shock velocity given by $M_s = 1.60$, the time interval between arrival of the shock wave and contact surface was measured at a station 12.5 feet from the diaphragm. Idealized shock-tube theory predicts a time separation of 8.8 milliseconds for argon under these conditions. The measured time between the shock transit and contact surface transit was 0.23 milliseconds. Further, the time separation of the shock wave and contact surface was found to be relatively independent of the distance between the diaphragm and the observing station.

The discrepancy between shock-tube theory and experimental results is explained in a qualitative fashion on the basis of the build up of a laminar boundary layer behind the shock wave. Calculations, based on flat plate theory, show that, for $M_s = 1.50$, a laminar boundary layer immediately ahead of the contact surface would have a thickness equal to 53% of the tube radius. For the regime investigated, the most influential parameter affecting the time separation of the shock wave and contact surface was shown to be the initial pressure, the empirical relationship being linear within the bounds of the pressures used.

E. K. Parks, USA

881. Devienne, F. M., Roustan, A. F., Bosc, H. L., Clapier, R. G., and Meslet, R. F., Use of the revolving arm method for the determination of the stagnation temperature in an ionized gas, AFOSR TN 59–196 (Lab. Mediterraneen de Recherches Thermodynamiques, Nice, France; ASTIA AD 211–473), 21 pp., Feb. 1959.

This technical note describes a technique of measurement in a rarified gas which seems to possess a net space charge. The ion density is inferred approximately by current flow to a probe which is held at several (variable) slightly negative potentials. The temperature of the probe is assumed to be the stagnation temperature plus temperature rise due to recombination. The measurements are interpreted in terms of calculations that have been made for free molecule flow.

Reviewer believes that the results would possibly be enhanced by a free molecule flow model which includes the long range coulombic interaction. In particular, it is possible for ions to be

trapped at the probe [cf. Bernstein and Rabinowitz, *Physics of Fluids* **2**, 2, p. 112, 1959]. E. E. Covert, USA

882. Anderson, S. B., Cooper, G. E., and Faye, A. E., Jr., Flight measurements of the effect of a controllable thrust reverser on the flight characteristics of a single-engine jet airplane, NASA Memo 4-26-59A, 45 pp., May 1959.

A flight investigation was made to determine the effect of a continuously controllable thrust reverser on landing-approach characteristics. Use of the reverser resulted in improved control of flight-path angle, reductions in approach speed for steep approach angles, and improved wave-off characteristics. A nose-down longitudinal trim change was present with increasing reverser deflection. From authors' summary

883. Lichtenstein, J. H., Fisher, L. R., Scher, S. H., and Lawrence, G. F., Some static, oscillatory, and free-body tests of blunt bodies at low subsonic speeds, NASA Memo 2-22-59L, 30 pp., Apr. 1959.

Some bodies suitable for entry into the earth's atmosphere were tested in the Langley stability tunnel and in the Langley 20-ft free-spinning tunnel. The results show that increasing the body flare and increasing the corner radius on flat-faced bodies had a beneficial effect on stability. A computed damping factor of about ½ or less indicated critical stability sensitive to disturbance and a damping factor of −2 indicated good damping.

From authors' summary

884. Wortmann, F. X., Investigation of three-dimensional vortex instability, AFOSR TR 59-59 (Institut für Aerodynamik und Gasdynamik, Technische Hochschule, Stuttgart, Final Tech. Rep.; ASTIA 216 624), 17 pp., Feb. 1959.

Report covers the development and construction of a laminar water tunnel designed for the investigation of a three-dimensional vortex instability of the laminar boundary layer on the concave wall. Both the assignment and the tellurium method have brought up problems for the solution of which entirely new approaches had to be found. Apart from the solution of a large variety of individual problems, a rigid, porous, corrosion-resistant wall surface was developed for boundary-layer suction.

From author's summary

Thermodynamics

(See also Revs. 823, 881, 913, 931)

885. Martinovsky, V. S., Thermodynamic characteristics for comparing cycles of heat power and refrigerating machines, Proc. 3rd Congr. Theor. Appl. Mech., Pangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957, 301-314.

Practical cycles operate with widely varying temperatures of the working substance. Author shows how introduction of rather simple equivalent temperatures permits construction of equivalent Carnot cycles which, in turn, allow an immediate estimate of the theoretical thermodynamic efficiency. The equivalent temperature of the heat input part A to B of a cycle is calculated thus: $\overline{T}_{AB} = \int_A^B TdS/(S_B - S_A)$. A similar averaging process is carried out for the heat-rejection part. The plot of the equivalent cycle on T-S coordinates then appears as a rectangle with opposite corners at $\overline{T}_{AB}$, S_B; $\overline{T}_{BA}$, S_A. Regenerative cycles, cycles with superheat, and corresponding refrigerating cycles are discussed in this way.

Concluding sections deal with the comparison of cycles of identical temperature limits, but differing in either their range of volume or pressure characteristics.

W. Hitschfeld, England

886. Andrews, H. I., Efficiency of locomotive smokeboxes, *Engineer, Lond.* **206,** 5370, 1008-1012, Dec. 1958.

In a steam locomotive the combustion products are drawn through the smoke box and chimney by steam expanding from the cylinder exhaust through blast pipes into the smoke box. Thus the engine has to work with a back pressure larger than atmospheric, and the energy which could be derived in full expansion is expended on compression of the combustion products from smoke box vacuum to atmosphere.

To define a rational efficiency, author employs the usual device of "replacing" the smoke box by a suitably idealized system of machinery, i.e. an isentropic steam expander utilizing the pressure difference between engine exhaust and atmosphere, and an isentropic compressor compressing the products from smoke box vacuum to atmosphere. There follows a tortuous argument—made difficult by the use of "energy" for both "energy" and "enthalpy," "adiabatic" for both "adiabatic" and "isentropic," and further confused by an irrelevant argument about kinetic energy terms—leading to an expression that can be derived in a few lines. The result seems to represent a more reasonable standard of comparison for smoke boxes than has hitherto been used.

Y. R. Mayhew, England

887. Baranowski, B., Interaction between diffusion and viscous flow in mixtures of rarified monatomic gases (in English), *Acad. Roy. Belgique Bull. Cl. Sci.* (5) **44,** 7, 647-660, July 1958.

While the author claims to extend Grad's method of solution to two-component mixtures, in fact the paper contains mainly some phenomenological remarks vaguely presented with a semblance of derivation from the kinetic theory. First, by assuming a special form for the distribution function, the author derives some classical equations valid in general [cf. Chapman and Cowling, "Mathematical theory of non-uniform gases," Cambridge, 1939 (2nd ed., 1953), §8.1]. In particular, the author's assertions that the "overall" equations are of the same form as for a simple gas hold in much greater generality than do his arguments. Eq. [28] would be the generalization of the Maxwell-Grad equation for the temporal evolution of the pressure tensor if it were correct. However, the author's special distribution function [13] has led to elimination of the third moments in terms of the first; in the case of a simple gas, this amounts to neglecting the heat flux altogether, while for the present case it amounts to assuming the heat flux of each species proportional to the diffusion velocity of that species. In §5 further phenomenological assumptions are added so as to eliminate the collision integrals and with them all justification for regarding the work as belonging to the kinetic theory at all.

C. Truesdell, USA

888. Gross, E. P., and Jackson, E. A., Kinetic models and the linearized Boltzmann equation, *Physics of Fluids* **2,** 4, 432-441, July-Aug. 1959.

Attention is directed to some unsatisfactory features of kinetic theory treatment of problems for which the linearized Boltzmann equation is applicable. The main defects are in the region where nearly free molecular flow conditions prevail. They can be overcome when the problems are treated by simplified kinetic models. In this paper, relations between the linearized Boltzmann equation and some models are established. The method is based on a comparison of the eigenvalue spectra of the respective collision operators. Particular attention is paid to inverse fifth molecules. This allows evaluation of the limitations of a given model and shows how more accurate models can be constructed. It is shown

how one may overcome the chief shortcomings of approximate solutions of the linearized Boltzmann equation.

From authors' summary by L. S. Dzung, Switzerland

889. Szaniawski, A., Relaxation phenomena in flow problems (in English), *Arch. Mech. Stos.* **10,** 5, 675–698, 1958.

This paper contains an analysis of the process of establishing thermodynamic equilibrium. Author's aim is to establish general equations of motion of a liquid with slightly disturbed equilibrium. Under such conditions additional terms appear in the equations of motion, connected with the "inertia" of the liquid defined in the most general manner as a tendency opposing the immediate attainment of the state of equilibrium.

According to the concept of relaxation phenomena in continuous bodies, author's reasoning is based on the hypothesis that common thermodynamic functions are not sufficient to describe the state of a continuous medium with disturbed equilibrium. Therefore it is necessary to introduce the so-called internal degrees of freedom. To relate these new variables to the common variables of equilibrium, author introduces the second law of thermodynamics in its general form connected with Onsager's theory of irreversible processes. To obtain final equations describing the process by means of common thermodynamic and hydraulic variables the variables of the "internal degrees of freedom" are eliminated from the general equations of the theory. This elimination is performed in the particular case of constant phenomenological coefficients. Author obtains equations of motion with additional integrodifferential corrections of the relaxation type. The relaxation correction appears among others in the equation describing the relation between the stress tensor and the strain-rate tensor (that is, under conditions of disturbed equilibrium a liquid ceases to be Newtonian).

Z. Szymanski, Poland

890. Biot, M. A., Linear thermodynamics and the mechanics of solids, Proc. U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 1–18.

"The thermodynamics of linear irreversible processes is presented from a unified viewpoint. This provides a new and synthetic approach to the linear mechanics of deformation of solids, which includes as particular cases the classical theory of elasticity, thermoelasticity and viscoelasticity. The first two sections constitute an introduction to the general concepts and principles of linear thermodynamics as developed in the author's earlier work. This is followed by the application of the general thermodynamic theory to thermoelasticity which combines the theories of elasticity, heat transfer, and their coupled effects into a single treatment. Some immediate consequences are derived such as the property of diffusion of entropy and certain fundamental relations with reference to thermal stresses. The introduction of inertia forces leads to a general formulation of thermoelastic dissipation of dynamical systems by Lagrangian methods. The second-order heat produced by the dissipation is evaluated. Linear viscoelasticity and relaxation phenomena are also a particular case of the thermodynamic theory. The resulting stress-strain relations with heredity properties are discussed. The operational formulation of these relations leads naturally to a formal correspondence with the theory of elasticity and to an operational-variational principle. The latter provides a generalization of Lagrange's equations in integro-differential form to the dynamics and stress analysis of viscoelastic structures. Some specific applications of these principles are presented."

In the opinion of the reviewer, author's discussion of the meaning of his symbols in terms of classical thermodynamics is unusually conscientious. Nevertheless, several important points require expansion or revision. The definition of the quantity ϕ should be further restricted because not all thermodynamic properties can be used to define a velocity or a flux. A nonhomogeneous condition of region I is not necessary to the argument, because this region must shrink to an elementary size if ϕ is to be defined as a vector, as it is implied to be. The heat quantity b, which is for an unspecified process, could have been avoided by reference to the Gibbs equation. No mention is made of the literature of availability and irreversibility in which the quanities V and D have been used with the same, though somewhat more general, implications as here.

J. H. Keenan, USA

Heat and Mass Transfer

(See also Revs. 561, 573, 613, 709, 799, 810, 836, 840, 841, 867, 888, 934, 948, 1014, 1015)

891. Newcomb, T. P., Transient temperatures in brake drums and linings, Instn. Mech. Engrs., Auto. Div., 13 pp., 1958.

Author applies the solution for the temperature distribution in an infinite slab with one face subjected to a linearly (in time) decreasing thermal flux and the other face perfectly insulated to compute the transient temperatures reached by automotive brake linings during uniform deceleration of the vehicle.

The Laplace transform is employed to obtain solutions for the problem which are fairly standard. However, the paper is valuable in that it includes an experimental verification of the solutions and extends the results to include the effect of repeated applications of the brake and the influence of fan-cooling upon the maximum temperature at the lining and drum interface.

W. A. Wolfe, Canada

892. Han, L. S., Laminar heat transfer in rectangular channels, *ASME Trans.* **81C** (*J. Heat Transfer*), 2, 121–128, May 1959.

A theoretical treatment is given of three cases of laminar heat transfer with linear heat input in long rectangular channels with fully established velocity profiles. The channels are formed by two parallel plates with interconnecting longitudinal ribs. In the first two cases (laminar flow and slug flow respectively) heat is transferred at uniform rate to the fluid along the parallel-plate surfaces with respect to the flow direction. The parallel plates also transfer heat to the interconnecting ribs or fins. These two cases have been treated by the method of orthogonal trigonometric series. It appears that a fin parameter defined as the product of the ratio of the fin thermal conductivity over the fluid thermal conductivity and the ratio of the width over the height of the fins is an important factor governing the Nusselt number.

The third case, which is solved with the same method, deals with the superimposed effects of natural and forced convection heat transfer in vertically mounted vertical rectangular channels.

J. A. Businger, USA

893. Abramowitz, M., Cahill, W. F., and Wade, C., Jr., Heat transfer in laminar flow through a tube, *J. Res. Nat. Bur. Stands.* **62,** 3, 101–105, Mar. 1959.

Paper assumes a parabolic velocity distribution and considers the effect of axial temperature variation. The solution for the temperature distribution is given as a series in which each term is the product of an exponential function of the axial coordinate and a function of the radial coordinate satisfying a boundary-value problem for a second-order ordinary differential equation. The eigenfunctions, which form a nonorthogonal set, and the corresponding eigenvalues are obtained by numerical integration of this equation. The coefficients in the series are obtained by satisfying the temperature initial condition in the least-squares sense. Asymptotic results useful in limiting cases are also presented.

D. W. Dunn, Canada

894. Offenhartz, E., and Weisblatt, H., Experimental determination of the turbulent heat transfer rate distribution along a slender blunt nosed body from shock tube tests, AVCO, Research & Advanced Development Div., RAD-TR-9-59-18, 24 pp., May 1959.

An experimental investigation has been undertaken using shock-tube techniques to determine the heat-transfer rate distribution about a blunt-nosed cone-cylinder body at zero and nonzero angle-of-attack.

At zero-degree angle-of-attack it was found that the Van Driest and momentum turbulent flow theories predict the trend of the experimental data for the entire body.

The heat-transfer data were correlated in terms of the ratio of measured heat-transfer rates at angle-of-attack to zero values. A simple engineering approach permits the calculation of this ratio which closely predicts the trend of the experimental data.

From authors' summary

895. Georgiev, S., Hidalgo, H., and Adams, M. C., On ablation for the recovery of satellites, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 171–180.

The absorption of aerodynamic heating by the ablation process is recognized as a powerful means of heat protection for vehicles re-entering the earth's atmosphere. The present report is concerned with an investigation of ablation for the recovery of satellite vehicles.

Satellite re-entry is characterized by deceleration and heating at high altitudes such that the Reynolds number should be low enough to insure a laminar boundary layer. Authors restrict their discussion to laminar heat transfer. In section (1) they discuss some requirements for good ablating materials and present briefly a theory for ablation; in section (2) are presented experimental ablation results for Teflon, obtained in an air arc wind tunnel which simulates the satellite re-entry environment; and in section (3) the results are applied to satellite re-entry and authors compare the heat shield weight required for an ablating material with a heat sink type material.

The results of the present investigation indicate that the requirements for satellite ablating materials are not severe. Further it is shown that Teflon, as an example, will absorb 4000 Btu/lb of ablated material while beryllium, which represents a good heat sink, can absorb only about 1000 Btu/lb.

From authors' summary

896. Glassman, I., and John, J. E. A., An unusual aerodynamic stagnation-temperature effect, *J. Aero/Space Sci.* **26,** 6, 387–388 (Readers' Forum), June 1959.

In a program concerned with the mixing of compressible jets with quiescent air, experimental measurements were obtained in which stagnation temperatures along the centerline of the jet (T_c°) were greater than either the uniform initial stagnation temperature of the jet (T_1°) or the ambient temperature (T_a). This effect was most evident when the initial Mach number was the greatest and when the ratio T_1°/T_a was at a minimum (unity for the actual experimental cases).

From authors' summary

897. Lancet, R. T., The effect of surface roughness on the convection heat-transfer coefficient for fully developed turbulent flow in ducts with uniform heat flux, *ASME Trans.* 81C (*J. Heat Transfer*), 2, 168–174, May 1959.

Experimental data are presented for the heat-transfer coefficient and friction factor in a smooth and a rough duct with a hydraulic diameter of approximately 0.035 in. The flow was fully developed and turbulent, and the heat addition was uniform over the length of the tube. The rough tube indicated appreciable increases in heat-transfer coefficient and friction factor. The smooth-tube friction factors corresponded to rough-tube values, indicating the difficulty involved in obtaining smooth surfaces for very small ducts.

From author's summary

898. Pustovoit, S. P., Transient thermal convection in a spherical cavity, *Appl. Math. Mech.* (*Prikl. Math. Mekh*) **22,** 4, 800–806, 1958. (Pergamon Press, 122 E. 55th St., New York 22, New York.)

Using spherical coordinates, author expresses convection equations for transient free convection case on a dimensionless basis. By inserting boundary conditions and assuming small Grashof number, a linear equation for successive approximations is obtained. Zero and first-order approximations are shown and typical results sketched. Conclusion is reached for the approximation that convection does not affect the rate of cooling of the liquid as a whole.

A. Sesonske, USA

899. Sevruk, I. G., Laminar convection over a linear heat source, *Appl. Math. Mech.* (*Prikl. Math. Mekh.*) **22,** 4, 807–812, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Solutions for the boundary-layer equations were found for the case of an infinite horizontal heated wire heating a fluid by laminar free convection. Solution in series form is only valid at distance from the source where its dimensions do not affect fluid flow.

A. Sesonske, USA

900. Nagiev, M. F., and Karamzin, P. V., Determination of the coefficient of heat emission of the flow in a tubular space when the hydrodynamic regime is in a transition stage (in Russian), *Izv. AzSSR* no. 5, 35–44, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6772.

A method, proposed by the authors, is explained for the calculation of Nusselt numbers in conditions of a hydrodynamical transition regime, when the surfaces of the tubes are being flown over longitudinally. By a transition regime the authors understand a regime where the motion is characterized by values for Reynolds numbers in the range of 2320 to 10,000. The method proposed is based on the assumption that, in the range of given R numbers, the breakdown of the laminar motion does not extend over the whole area of the core of the flow. Together with this, authors also assume the existence, within the nuclear limits of the flow, of regions of laminar and turbulent types of flow. Nusselt number N is proposed to be determined in conditions of a transition regime as the sum of

$$N'_{zb} = LN_{zbl} + TN_{zbt}$$

Here, N'_{zb} is Nusselt criterion with R = 2320 to 10,000; N_{zbl} ibid, with a laminar motion and R = 2320; N_{zbt} ibid, with a turbulent flow and R = 10,000; the coefficients l and t characterize the distribution in the flow of the laminar and turbulent regimes of flow. The coefficients l and t are assumed to be linearly dependent on Reynolds number R for the flow of liquid in the transition state. A comparison is given of the tests carried out by the authors with water with the experimental data of I. T. Alad'ev, M. A. Mikheev and O. S. Fedynskii [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 1951]. The tests described were carried out with small temperature changes in the flow between the initial and end sections of the working portion. When analyzing the test data the linear principle was adopted of change of temperature in the direction of the motion. The value of Nusselt number, corresponding to the laminar regime (N_{zbl}) was determined by the Zieder and Tate formula; the number corresponding to the turbulent flow N_{zbt}, by Kranssol'd's formula, as modified by M. A. Mikheev.

No account is given in the paper of the setting for the experiments nor descriptions of the tests. The experimental observations of the authors were also analyzed by the customary method, based on the introduction of a correction coefficient into the formula, applicable for the determination of the N number with $R >$ 10,000. The value of the correction coefficient was calculated

according to V. M. Ramm's data [Teploobmennye-apparata (Heat exchange apparatus), Goskhimizdat, 1948]. From the curve published in the paper it would appear that the results of the experiments worked over by the customary method agree somewhat better with the experimental data given by Alad'ev, Mikheev and Fedynskii than those worked over by the method proposed by the authors. Some errors have occurred in the formulas given in the paper.

M. D. Vaisman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

901. Wolf, H., Heating and cooling air and carbon dioxide in the thermal entrance region of a circular duct with large gas-to-wall temperature differences, *ASME Trans.* **81C** (*J. Heat Transfer*), 4, 267–279, Nov. 1959.

The local heat-transfer characteristics for air and carbon dioxide in the thermal entrance region have been determined experimentally and are compared with predicted values computed from an extension of the theoretical analysis due to Deissler. The experiments were conducted in smooth round tubes having a fully developed turbulent velocity profile and a uniform temperature distribution at the entrance. The boundary conditions of uniform heat flux for heating the gas, and wall temperature constant and variable with axial distance for cooling the gas, were investigated with large temperature differences between the gas and the tube wall. For heating, the experimental results yielded one per cent thermal entrance lengths ranging from 11 to 27 diameters over the bulk Reynolds number range from 50,000 to 246,000. For cooling, one per cent thermal entrance lengths ranging from 12 to 26 diameters were obtained for bulk Reynolds numbers ranging from 17,000 to 218,000. The agreement between theory and experiment was favorable in most cases. From author's summary

902. Cooper, M., and Stainback, P. C., Influence of large positive dihedral on heat transfer to leading edges of highly swept wings at very high Mach numbers, NASA Memo 3-7-59L, 18 pp., Apr. 1959.

The results of this study show that the incorporation of large positive dihedral on highly swept wings can shift, even at moderately low angles of attack, the stagnation-line heat-transfer problem from the leading edges to the axis of symmetry (ridge line). An order-of-magnitude analysis (assuming laminar flow) indicates conditions for which it may be possible to reduce the heating at the ridge line (except in the vicinity of the wing apex) to a small fraction of the leading-edge heat transfer of a flat wing at the same lift. Furthermore, conditions are indicated where dihedral reduces the leading-edge heat transfer for angles of attack less than those required to shift the stagnation line from the leading edge to the ridge line. From authors' summary

903. Dyban, O. A., Determination of the temperature of a flow between heating and cooling surfaces (in Russian), *Dop. Akad. Nauk URSR* no. 3, 269–272, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6796.

Paper determines analytically the temperature at an arbitrary point in a strip between the generatrixes of two bodies with different heat potentials. Author derives an equation for the mean temperature of the cooling flow, the experimental apparatus used consisting of two hollow cylinders of different diameters, slid one over the other, a hot liquid going through one cylinder and a cold one through the other. A. V. Kur'yato

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

904. Dorgin, F. R., An "insulating" boundary-layer experiment, *J. Aero/Space Sci.* **26,** 7, 450–451 (Readers' Forum), July 1959.

If an upstream section of a face is cooled below recovery temperature, the uncooled surface downstream will be swept by a flow with an energy deficiency relative to the uncooled flow. The surface temperature over the uncooled portion will remain below recovery temperature for a finite distance. The note describes experimental results on a conical surface. Comparisons with theoretical predictions show good agreement.

L. S. Dzung, Switzerland

905. Veronis, G., Cellular convection with finite amplitude, in a rotating fluid, *J. Fluid Mech.* **5,** 3, 401–435, Apr. 1959.

Author succeeds in combining the problems of Chandrasekhar [AMR **7** (1954), Rev. 358], and Malkus and Veronis [AMR **12** (1959), Rev. 1506]. The cell boundaries are distorted by the rotation. Several types of instability are compared. The influences of the Prandtl and Taylor numbers on the preferred type of cellular motions and on the convective heat transfer are elucidated. Valuable data for mercury and air are calculated.

H. A. Vreedenberg, Holland

906. Goodman, S., Russell, S. B., and Noble, C. E., Effect of internal radiant heat transfer on temperature distribution, thermal stress, and deflection in box beams, *J. Res. Nat. Bur. Stands.* **62,** 4, 175–181, Apr. 1959.

Author solves title problem by computer for thirteen box beams with thermal and elastic properties linearly dependent on the temperature. Different combinations of wall thickness, heating rate and interior and exterior emittances are considered. Numerical scheme of analysis used is similar to that introduced by Dusinberre, *Trans. ASME* **67,** 703–712, 1945. An increase in the interior surface emittance of the box is shown to reduce thermal deflections and stresses. The amount of the reduction in these quantities is shown to depend on the rate of heat input to the box; the greater the rate of heat input the smaller the reduction. Results of three experimental tests are given for relatively thick box beams under a slow rate of heat input and found to be in fair agreement with the theory. Reviewer feels that heating rates higher than those considered by authors may be encountered and that the possible inelastic behavior of the material should be treated in the total problem. E. A. Trabant, USA

907. Vos, A. S., Superheating and distribution of the temperature in the liquid and vapor of boiling liquids (in Dutch), *Ingenieur* **71,** 7, 0.17–0.20, Feb. 1959.

A survey is given of the temperature distribution when the liquid and vapor are in equilibrium, when there are vapor bubbles and when they are absent, an inquiry into the superheating temperature of the heater producing the first vapor bubbles, and a discussion of some effects influencing the maximum heat transfer in nucleate boiling.

In liquids without generation of bubbles the superheating effect will be some degrees Celsius; when there are bubbles, the superheating of the liquid is limited to some tenths of a degree Celsius. In the boundary layer immediately against the heater the superheating is much higher. From author's summary

908. Lavrova, V., Experimental investigation of heat emission by boiling freon-12 (in Russian), *Kholodil'naya Tekhnika* no. 3, 55–61, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6783.

The study deals with the investigation of the heat emission from the hot outside surface of a single tube of liquid freon-12 in conditions of natural convection. A detailed description is given of the apparatus used. The experiments were carried out at a pressure of 1.86 atm (which corresponds to a saturation temperature for the freon-12 of $-15°$). The results of the experiments showed that the boiling of the liquid began at a value for the specific thermal load of $\geq$ 2000 Kgcal/m^2 hr, while the transition to

the actual boiling state was accompanied by jump-like increases of the coefficient of heat emission. A comparison of the experimental data with the different calculation semi-empirical relations showed good agreement with the relation proposed by Kruzhilin.

V. P. Mugalev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

909. Romanov, V. V., Calculations for evaporation by the method of thermal balance (in Russian), *Trudi Gos. Gidrolog. In-ta* no. 54 (108), 75–79, 1956; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5573.

This is a preliminary communication on the results of studies aimed at reducing the complexity of the method of thermal balance as applied to the determination of evaporation. The proposed simplification can be condensed into the following: (1) The calculation formula for the determination of evaporation u, expressed in mm/hr

$$u = (R_s - Q_n)/[60(1 + 0.64\Delta T/\Delta e)] \qquad [1]$$

through the radiation balance R_s, the flow of heat into the soil Q(cal/cm^3 hour), and the difference between the temperature ΔT(°C) and the elasticity of the water vapor Δe(mb) at two levels in the layer next the earth is applicable directly to the mid-monthly data for every separate hour of the 24-hr day. (2) The flow of heat into the soil Q_n is disregarded, and an approximate correction is then introduced for the influence of Q_n, obtained by replacing the denominator in [1] by the mid-month (averaged for all the hours of the 24-hr day) value. (3) The differences between ΔT and Δe are determined by the recorded readings of the thermographs and hydrographs set up at two different levels. (4) The radiation balance R_s is not determined instrumentally, but is calculated from standard meteorological data, namely $R_s = R_n - R_e$ when the absorbed radiation R_e is obtained from the empirical formula derived by A. P. Braslavskii and Z. A. Vikulina [Standards for evaporation from the surface of reservoirs; Gidrometeoizdat, 1954] in which the effective radiation R_e is derived from nomograms by T. V. Kirillova and E. D. Kovaleva [*Trudi Gl. Geofiz. Observ.* no. 27 (89), 1951]. In consequence of these simplifications it was found unnecessary to employ special apparatus (remote psychrometers, balances) or to make calculations for each hour with subsequent totalling within the given month. An analysis is carried out of sources of error in the method. Calculations were made by the simplified method. The averaged data for the calculations were compared with the results of the determination of the evaporation by the water-balance method; the agreement was good. Comparison with the calculations by the customary method of determining the thermal balance was not done.

Note by the abstractor: Among the sources of error no mention is made of the application of the nonlinear formula [1] to the averaged data. The corresponding error is only small in the case where the 24-hr course of all values figuring in this formula varies but slightly within the given month. L. S. Gandin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

910. Nissan, A. H., Kaye, W. G., and Bell, J. R., Mechanism of drying thick porous bodies during the falling rate period, Part I: Pseudo-wet-bulb-temperature, *AIChE J.* **5,** 1, 103–110, Mar. 1959.

The drying of two highly porous thick textiles is studied and compared. Extremes are chosen in that one package is composed of a Terylene (British form of a polyester fiber) net fabric of open structure and the other of a woolen flannel of close structure. The cloths are wound as bobbins and dried by hot air streaming in a wind tunnel, the air flowing parallel to the axis of the cylinder of material. The weight of water as drying progresses is measured by a balance, and thermocouples within the bobbin provide a temperature record.

On investigation of the thermal conductivity of the dry structure, it is found that whereas the coefficient for the wool-air mixture is constant throughout, the coefficient for the Terylene-air mixture applies only in the depths, the apparent thermal conductivity growing larger toward the surface and with increasing air speed, as if the heat transfer through the open structure is assisted by some form of air penetration.

As the thick textiles dry, the rate of evaporation falls off, since heat and water vapor have to pass through an increasing layer of dry material. While this is occurring, a constant temperature, the "pseudo-wet-bulb temperature," is established throughout the wet cloth. This state of equilibrium may be expressed as an equation between the rate of heat conduction inward and that required to produce the vapor diffusion outward. From the equation the pseudo-wet-bulb temperature can be calculated.

From authors' summary by R. L. Young, USA

911. Bell, J. R., and Nissan, A. H., Mechanism of drying thick porous bodies during the falling-rate period, Part II: A hygroscopic material, *AIChE J.* **5,** 3, 344–347, Sept. 1959.

A further analysis of the second falling-rate period in the drying of thick highly porous textile structures is made, this time in the case of drying wool, special attention being paid to the adsorbed water held by the wool in the air-dry region. As the solid-to-void ratio is low, the quantities of adsorbed water are small and have little effect on the general equilibrium. Values of thermal conductivity are calculated for wet wool.

From authors' summary by R. L. Young, USA

912. Furman, T., and Hampson, H., Experimental investigation into the effects of cross flow with condensation of steam and steam-gas mixtures on a vertical tube, Instn. Mech. Engrs., Prepr., 13 pp., 1958.

Atmospheric pressure heat-transfer measurements were made of condensing pure steam and mixtures of steam and nitrogen up to 6% nitrogen by weight, on the outside of a vertically mounted 5/8-in. o d copper tube, water-cooled. Tests were made in steam-filled wind tunnel on single tube located in free stream. Steam flows varied from zero to 20,000 lb/(ft^2/hr). Heat-transfer rates increased with flow rate in case of film condensation. With dropwise condensation and pure steam, heat transfer remained constant after steam flow rate of 1000 lb/(ft^2/hr). However, with nitrogen in steam, higher steam flow rate gave higher coefficient over entire range.

During most tests, surface conditions on tube remained unchanged—promoter remaining in place for dropwise test, and oxidation of tube surface not occurring during film condensation test. Results are shown only in terms of overall coefficients. Reviewer believes that data is ample to permit calculating individual coefficients even though waterside heat transfer is higher than given by Dittus-Boelter equation because (as authors indicate) end effects created added turbulence.

Reviewer considers test program thus far to be of somewhat limited value because no measurements were made under vacuum. Major industrial application is in design of surface condensers operating at about 1/30 atmosphere. While mass flow rates are in the right range, either temperature difference or viscosity effects enter to produce uncertainty in extrapolation of these test values to those for low pressure, low temperature steam. Also, no study was made of influence of presence of other tubes or interference to heat transfer resulting from condensate carried along with steam from other tubes. D. Aronson, USA

913. Sokolova, E., Investigation of heat emission during the condensation of freon (in Russian), *Skolodil'naya Tekhnika* no. 3, 71–75, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6781.

A description is given of the results of the experimental determination of the coefficient of heat emission when freon 22 is condensed on the outer surface of single horizontal smooth and ribbed pipes (while investigating the free motion). A scheme is put forward showing the experimental setting. In all the experiments film-condensation took place which, with increase of the thermal loading, caused the surface of the film to become more wavy. The experiments were carried out at temperatures for the condensation of 30, 40 and 50° for each pipe. A criterial formula is proposed characterizing the heat emission of freon 12 and freon 22 when being condensed, which agrees satisfactorily with the results of tests on smooth and ribbed pipes made of copper and steel. It is noted that for smooth tubes the value of the coefficient of heat emission during condensation of freon 22 was 10% greater than of freon 12, while for ribbed pipes the difference did not exceed 5%. V. P. Mugalev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

914. Christian, W. J., and Kezios, S. P., Sublimation from sharp-edged cylinders in axisymmetric flow, including influence of surface curvature, *AIChE J.* **5,** 1, 61–68, Mar. 1959.

An experimental investigation was performed on the mass transfer by sublimation from the outer surfaces of hollow naphthalene cylinders, 0.75 and 1.00 in. in diam, in parallel air streams at velocities between 20 and 120 fps. Local mass transfer rates on the cylinders were obtained by a profilometric technique consisting of accurate determinations of changes in radii of the subliming surfaces at points along elements of the cylinders.

Local coefficients of mass transfer obtained with laminar boundary layers for Reynolds numbers (based on axial length) between 12,000 and 100,000 were found to be up to 8% greater, because of surface curvature, than corresponding values for flat surfaces. Moreover, comparison of the mass-transfer data with a theoretical prediction for laminar skin friction on circular cylinders indicates an effect of surface curvature on the Chilton-Colburn anology between momentum and mass transfer amounting to as much as 6% in the range of air velocity employed. For turbulent boundary layers obtained by artifical triggering of turbulence at the leading edges of the cylinders no effect of surface curvature was found. The results obtained for Reynolds numbers of 40,000 to 1,000,000 are lower than previously published correlations of turbulent heat, mass, and momentum transfer, when compared by the Poelter, Martinelli, and Jonassen form of the analogy.

From authors' summary by R. G. Nevins, USA

915. Lees, L., Similarity parameters for surface melting of a blunt-nosed body in a high velocity gas stream, *ARS J.* **29,** 5, 345–354, May 1959.

The problem is treated as a two-phase gas-liquid boundary layer. The velocities of the molten liquid layer relative to the body indicate a low Reynolds number and consequently laminar flow. The analysis is carried out for low enough heat-transfer ratio such that no appreciable vaporization takes place at the liquid-gas interface. Consequently the flow of gas is virtually unaffected by the presence of the thin matter-liquid film. A preliminary study is made for effects of mass addition into the gas-phase boundary layer. Dynamic and heat-transfer properties of the gas-liquid layer are derived. Numerical calculations are included for the determination of the velocity ratio in the two layers, the heat transfer and melting rates on the surface. S. Eskinazi, USA

916. Sutton, G. W., A comparison of several approximate theories of melting ablation, *J. Aero/Space Sci.* **26,** 6, 397–398 (Readers' Forum), June 1959.

Numerical results obtained from several approximate theories of melting ablation are compared to the results obtained from similarity solutions by numerical integration suggested by author in his previous work. Conditions are analyzed for an axially symmetric stagnation point, where the similarity solution is exact for a glass with the properties and with flight regime assumed in this note. Author concludes that, for the material and interface temperature chosen in this analysis, all approximate theories yield heating and melting rates which are too large, in some instances as high as 25%. In practice, this error seems to be more significant for ablation with evaporation than for the melting evaporation alone.

Author's conclusions seem to be subject to serious doubt in view of the premises of his analysis. Reference (1) [Bethe, H. A., and Adams, M. C., title source **26,** 11, p. 768, Nov. 1959] critically evaluates the numerical conclusions for the case analyzed by its authors and shows that if proper numerical values are assumed for boundary parameters, i.e. the heat-transfer rate rather than the surface temperature, the agreement with numerical results of the similarity theory (and with experiment) is close to within a few percent. This reviewer feels that similar objections could be raised with regard to other theories considered by the author. It is difficult of course to form a comparable opinion about the validity of author's comparison with a method to which he refers but which has not been published in open literature.

P. Zarwyn, USA

917. Sutherland, W. A., Reactor heat transfer—a preliminary design procedure, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59–SA–16, 5 pp.

Power reactors are primarily a heat source for the common Rankine or Brayton-cycle heat engines. As such, preliminary design studies of power-reactor cores should be investigated from a heat-transfer-performance point of view. This method, for nonboiling single-phase fluid systems, is used, together with a core effectiveness, to compare various fuel element geometries and primary coolants, as heat-transfer capability versus pumping power. It is thus possible to make rapid and accurate surveys of core designs. From author's summary

918. Macey, R. I., A quasi-steady-state approximation method for diffusion problems, Part I, Concentration dependent diffusion coefficients, *Bull. Math. Biophys.* **21,** 1, 19–32, Mar. 1959.

This paper describes a method for dealing with diffusion problems which is similar to methods recently developed by engineers for heat-conduction problems [AMR **11** (1958), Rev. 651; Y. T. Yang and A. Szewczyk, *Trans. ASME* **81C** (*J. Heat Trans.*), p. 251, 1959].

The method is applied to one-dimensional problems with linear exponential and inverse quadratic concentration dependence of the diffusion coefficient. The results are compared with available numerical solutions. It is found that there is a discrepancy averaging 8% in the estimate of the cumulative amount of material diffused across a surface.

Apparently the engineers have carried the method to a somewhat higher degree of accuracy at the expense of additional work. The independent development of a similar technique in two separate fields is interesting. W. Squire, USA

919. Monin, A. S., Cf diffusion with a finite velocity (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 3, 234–248, 1955; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6805.

Turbulent diffusion of some sort of an admixture in a gas is looked upon as the result of the action of chaotically distributed separate streamlets in the medium, identifiable by their varied sizes and velocities. The type of streamlet and coordinate of the suspended particles in it form a random Markov process. The first case examined is that of streamlets of two types, differing from each other only by the direction of velocity. Here the process is described by means of a telegraphic equation. In a more complex

case a system n of differential equations is obtained, where n is the number of streamlet types. The simplest case for two streamlets is examined in detail: a solution is derived to act as a source of origin, forms are established for the boundary transition to the pure wave equation and the equation of heat conductivity, etc. Finally, studies are directed to the steady turbulent regime in the atmospheric layer next the earth, where the flow characteristics depend considerably on the vertical coordinate. It should be noted that the asymptotic behavior of the solutions of equations obtained here with $t \to \infty$ (t being time) coincides with the solutions of the corresponding equations of the parabolic type, when, for the atmospheric conditions, the asymptote is attained in a matter of several tens of seconds. Therefore, for the majority of practical problems use can be made of the usual scheme for the process of diffusion with an infinitely great velocity.

E. M. Dobryishman
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

920. Jaeger, J. C., The analysis of aquifer test data or thermal conductivity measurements which use a line source, *J. Geophys. Res.* **64,** 5, 561–564, May 1959.

This paper presents a simple and useful method for determination of thermal conductivity and diffusivity from two temperature measurements taken at different times near an infinite line source of known strength. The method is very useful in that the radial distance from the heat source is not needed, nor are the other properties of the medium. The method is also applicable to the problem of drawdown in the neighborhood of a pumped well. It makes use of the ratio of the values of the drawdown at any two times and a graph computed from the theory. It has the advantage over existing procedures in that it is available for the analysis of isolated results and for small values of the time.

This general method of using the ratio of the values of the drawdown or temperature at a sequence of times in conjunction with a theoretical curve is not confined to the case of a line source, but is applicable to many other situations.

R. V. Dunkle, Australia

921. Swann, W. F. G., Theory of the A. J. Joffe method for rapid measurement of the thermal conductivity of solids, *J. Franklin Inst.* **267,** 5, 363–380, May 1959.

An exact solution is presented for the case where a block of high thermal conductivity is fastened to a block of low thermal conductivity representing the unknown material. The thermal conductivities and masses of the two blocks are such that one may assume that the block of high thermal conductivity has a temperature which, though time-dependent, is constant throughout the mass, although the temperature may vary throughout the block of low thermal conductivity when its outer surface is suddenly raised to a temperature τ_∞ and kept there. If θ is the excess of the temperature at some point over τ_∞, the general problem consists in finding θ as a function of distance and time (assuming a two-dimensional heat flow). The two cases where thermal resistance at the contact interface between the two blocks may or may not be present are discussed and relations developed; however, the actual complete expression for θ as a function of distance and time is given only for the case where thermal resistance at the interface is neglected. Y. S. Touloukian, USA

922. Sheer, C., Mead, L. H., Rothacker, D. L., and Johnson, L. H., Measurement of thermal diffusivity of various materials by means of the high intensity electric arc technique, WADC TR 57-226 (PB 131 601; ASTIA AD 142 093), 53 pp., Nov. 1957.

Studies have been made of the tail flame of a high intensity electric arc to determine its suitability as a medium for testing materials under sustained high-temperature gaseous flow. Efforts reported center on the establishment of an electrode geometry for stable operation, measurements of the temperature and velocity distribution in the tail flame at varying ambient pressure, and qualitative observations of the electrodynamic, magnetic and thermodynamic properties of the tail flame. Data of diffusivity measurements agree with literature in order of magnitude. Refinements in the instrumentation and evaluation techniques remain to be done. From authors' summary by W.-H. Chu, USA

923. Cladis, J. B., Simulation of thermal environment in space, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-26, 4 pp.

The need for a ground facility which can simulate the thermal environment in space is becoming more acute as the instrumentation of earth satellites and space vehicles evolves in sophistication. The paper describes two possibilities which can be used to test thermal designs. One is capable of a high degree of simulation of the thermal condition in space but is costly. The other is used at LMSD. From author's summary

Combustion

(See also Revs. 886, 950)

924. Sage, J. A., and Weinberg, F. J., An attempt at measuring homogeneous ignition temperatures, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 464–469.

The principle of the method investigated lies in supplying ignition energy in two steps. The gas is first heated homogeneously to a known temperature Tg ($< T_i$) and then only the additional energy E required to effect ignition is supplied and measured. As Tg is increased from room temperature to that at which pre-reactions are first detected, E falls. Extrapolating a graph of E against Tg to zero E gives the temperature T_i at which no further energy would be necessary to ignite the gas.

Experimentally a flow system is used allowing latitude in varying residence times by flow rate variation and maintaining pressure constant.

Present work was carried out on ethylene-air mixtures, the ignition tube being a translucent silica tube 9 cm in diameter and 46 cm long. Values of ignition temperatures have thus been measured over a range of ethylene-air ratios. Results show that ignition temperatures obtained are about 150 C higher than the accepted values of auto-ignition temperature for ethylene-air mixtures. P. Laffitte, France

925. Dixon-Lewis, C., and Isles, G. I., Limits of inflammability, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 475–483.

Paper is another in the argument concerning whether or not flammability limits are fundamental properties of flammable mixtures. Authors used flat flame burner wherein combustion occurs between two planes which are independently variable as to both position and temperature. By varying both parameters, authors show flammability limits to be function of apparatus and environment and therefore conclude that flammability limits are not functional properties. F. W. Bowditch, USA

926. Chirkin, A. P., Intensifying the ignition capacity of a solid fuel (in Russian), *Trudī Khar'kovsk. In-ta Inzh. Zh.-d. Transp.* no. 30, 3–7, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10877.

Author deduces the basic formulas relating to the process of combustion of a solid fuel, in a layer and in a suspended state. The influence of various factors on the intensity of ignition is

analyzed, and author comes to the conclusion that the maximum intensity of combustion is reached in the layer process and refers to the basic ways for attaining this intensity.

V. V. Smirnov

Courtesy Referativnyi Zburnal, USSR
Translation, courtesy Ministry of Supply, England

927. Richmond, J. K., Grumer, J., and Burgess, D. S., Turbulent flame propagation by large-scale wrinkling of a laminar flame front, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 615-620.

Evidence is presented that leads to the important result that there are two distinct modes of burning in a premixed turbulent flame. In one, the flame burns within the potential core. In the other, the flame burns in the mixing zone. In the latter region, the flame resembles a flag waving in the breeze, the flame emissivity is symmetric about the mean flame position, the flame thickness increases linearly with distance, and the turbulent flame speed appears to be equal to the laminar burning velocity plus a term proportional to the flow velocity. An explanation is offered for this result which differs somewhat from previous explanations, for instance, Eq. [13] of AMR **7** (1954), Rev. 3747.

A. A. Putnam, USA

928. Khromtsov, V. A., Investigation of pressure effect on the parameters of turbulence and on turbulent burning, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 609-614.

Premixed propane/air is drawn in through a burner tube and a turbulence grid into a combustion chamber which can be maintained at a required low pressure. The grids can be varied in regard to number of holes and size of holes. The turbulence parameters of the flow were determined by photographing the diffusion wake of luminous particles behind a point source in the flow. The turbulent burning velocity was determined by measuring the flame front area, while the thickness of the turbulent zone of combustion was taken as the axial distance of the temperature rise. It was found that the intensity of turbulence and the coefficient of turbulent diffusion varied as the 0.34 power of the pressure; the scale of turbulence was independent of pressure; the turbulent burning velocity for a fixed grid varied as the 0.4th power of the pressure, while the thickness of the turbulent zone of combustion increased as pressure was reduced. M. W. Thring, England

929. Jensen, W. P., and Shipman, C. W., Stabilization of flame in high speed flow by pilot flames, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 674-680.

The objective of this paper was to study the problem of ignition of fuel-air mixtures by pilot flames at velocities approximating those found in high output burners. Lean ignition limits of high-velocity streams of propane-air containing a low degree of turbulence were determined using coaxial hydrogen-air pilot flames as the ignition source.

A useful review of previous work in this field is given in the first part of the paper. Authors tested the possibility that the mechanism of ignition depends on the pattern of mixing between the hot pilot gases and the cold main-stream gases as well as the time of contact between the hot and cold gases. They attempted to correlate the ratio u_p/u_s with lean ignition limits since this ratio was a function of the composition pattern. (u_p = velocity of hot pilot gases based on pilot-tube cross section and u_s = velocity of main stream). It was found that the u_p/u_s ratio did not provide complete correlation.

The following conclusions are made: (1) While absolute size of mixing region is important, the nature of flow in the region of contact between burned and unburned gas plays a major role in determining the limits of ignition (or stability). (2) In general, with a stable pilot flame, there is a value of u_p/u_s beyond which no decrease in lean stability limit results from increased pilot feed rate at fixed pilot diameter. For example, for pilot flames between 1/8 in. and 1/4 in. in diameter, no advantage is to be gained in increasing the pilot feed rate beyond $u_p/u_s = 3$.

J. M. Singer, USA

930. Gol'denberg, S. A., and Khitrin, L. N., The influence of preheat of fuel mixture and the pressure of the surrounding medium on the stabilization limits (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 136-139, Feb. 1957.

931. Campbell, E. S., Hirschfelder, J. O., and Scholit, L. M., Deviation from the kinetic steady-state approximation in free-radical flame, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 332-338.

Authors are concerned with the mechanism of the free radical flame, a model involving two reactions: that in which free radicals are generated, and the main reaction catalyzed by the free radicals. To resolve the controversy over the effect of the steady-state approximation, the general hydrodynamic equations with reaction, etc., are integrated without *a priori* assumptions. Then the effect of the parameter ω, the ratio of the specific rate for the free radical to that of the main reaction, is examined. This parameter is significant because recent studies critical of diffusion flame theory indicate that, for high values of ω, the flame will maintain the steady state and will be insensitive to variations of the diffusion coefficient.

A number of simplifications and assumptions are introduced with the specific purpose of yielding a particular solution of the general equations without affecting the significance of qualitative results of the analysis. By these means, the equations reduce to a set involving the parameter ω. A numerical method is described for solving such a set subject to the asymptotic boundary conditions usual in flame theory. The results show the dependence of various flame properties, such as reaction and mass flow rates, on ω. In comparison with the analysis of Klein [AMR **11** (1958), Rev. 1042], which expresses the solution as a polynomial in ω but requires as input initial approximations for the mol fraction, the present method is more general and can be extended to complex flame systems. R. A. Stern, USA

932. Sobolev, G. K., High-temperature oxidation and burning of carbon monoxide, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 386-391.

Experimental procedure uses round cylindrical burners of 7, 10, and 14-mm diameter at normal pressure. Mixtures of CO, O_2 and N_2 have been investigated. Results are given on dependence of reaction rate on oxygen concentration and on carbon-monoxide concentration.

Conclusions reached are as follows.

(1) In the high-temperature CO oxidation in the after-burning zone, order of the overall reaction with respect to oxygen is one at low concentration and 0.20 at higher concentration.

(2) Under conditions of flame combustion the order with respect to excess oxygen is 0.25 and with respect to the excess carbon monoxide is 1.0.

(3) The principal kinetic parameters taking place in the flame front agree sufficiently well with the characteristics of the process formation of CO_2; however, absolute values of the rates of these processes differ by two orders.

(4) This difference may be due to the specific conditions of the reactions taking place in the flame front. conditions possibly re-

lated to the substantial deviation of the system from conditions of thermal and chemical equilibrium. R. Delbourgo, France

933. Hooker, W. J., Shock tube studies of acetylene decomposition, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 949–952.

934. Marshak, J. L., The study of heat exchange which takes place in vertical cyclone combustion chambers (in Russian), *Teploenergetika* no. 11, 20–25, Nov. 1958.

Author's purpose is to get a calculation formula for the heat transfer in vertical, pulverized coal-fired, cyclone combustion fore-chambers of steam boilers based on experiments made by himself. These were done at the Zakamst Thermo-Electric-Station with a 240 *t/h* boiler of 30 atm steam, superheated at 420 C. The furnace consisted of 4 vertical cyclone combustion fore-chambers, each of 2.0-m diam and 4.0-m length, formed of external pinned 83/5-mm steel tubes, at 132-mm intervals. The radial pins, 10-mm in diam and 12-15 mm long, were helically staggered, at 32 mm axial intervals and 18° inclination.

For the efficiency of the radiation screens author obtained the formula

$$\varphi = (0.53 - 0.25 \cdot 10^{-3} t_s)(1.36 - 0.06\ A)$$

where t_s is the centigrade slag mean temperature, quoted approximately 50° below slag fusion temperature or 100 C below flame temperature of furnace and A the slag content of fired coal, in parts of unity.

With the notations t_a and t_{fl} for the adiabatic combustion and the flame temperatures in °C, author arrives at the empirical formula

$$\theta = (t_{fl} + 273)/(t_a + 273) = T_{fl}/T_a = 1 \cdot \exp(-1.12\ B_o^{-1/3})$$

for B_o, the Boltzmann number, between 1.5 and 4.4, and consequently to the following approximate expression of the unit heat transfer

$$q_1 = \frac{B \cdot Vc\ T_a}{H} \cdot \exp \cdot (-1.12\ B_o^{-1/3})$$

where H is the radiation screen surface, B the hourly burned fuel, Vc the mean thermal capacity of the gases leaving the furnace. This formula is recommended by the author for cyclone combustion chambers. It is simple and handsome. However, reviewer believes that even author's Fig. 6 permits a linear approximation of the ratio θ, e.g., $\theta \approx 0.68 + 5.4 \cdot 10^{-2} B_o$, which leads to a more convenient practical formula for the heat transfer.

L. G. Hamburger, Roumania

935. Codegone, C., A law of similarity for temperatures in enclosed turbulent flames, *Combustion and Flame* **1,** 2, 194–198, June 1957.

936. Lyshevskii, A. S., A method for numerical determination of the fuel jet length in dense air (in Russian), Construction, research, trial of automobiles, no. 2, Moscow, Mashgiz, 1956, 44–53; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 399.

A formula for determination of the length of flare is produced, based on the assumption that the fuel jet injected by a cylindrical nozzle into highly compressed air forms the free turbulent stream. The value of the nondimensional coefficient in the formula is determined on the basis of experimental results. A sample calculation is given. The calculations are compared with experimental results of several authors. V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

937. Sunavala, P. D., Hulse, C., and Thring, M. W., Mixing and combustion in free and enclosed turbulent jet diffusion flames, *Combustion and Flame* **1,** 2, 179–193, June 1957.

938. Karlovitz, B., The growth and burn-out of flame surface in a turbulent stream, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 604–608.

Flames in many practical applications are assumed to fill available space with distributed luminosity and to consist of randomly fluctuating combustion waves spread throughout the whole volume. A method of calculating the effective area of these combustion waves along the length of the flow based on the assumption that they are generated by turbulent motion is developed, and one particular example is worked out but not compared with practical measurements. M. W. Thring, England

939. Hogg, A., Holden, C., and Siddall, R. G., Use of aerodynamic models in the study of industrial furnaces, particularly open hearth furnaces, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 639–650.

Comparison of a 1/24 scale model with a full-scale oil-fired open hearth furnace has shown that the results did not fully agree. The difference of the fuel/air ratio at similar points has been examined and expressed by a regression curve. If $f/a_{(model)}$ is plotted against $f/a_{(furnace)}$ a parabolic curve is obtained which could be used to correct the results of the model. The reasons for the deviation are discussed. The difficulty of simulating the air infiltration and others of minor influence cannot be responsible for the full difference. However, authors have found that the jet fluid (steam/oil mixture in the furnace, hot air in the model) does not diffuse outward as fast as it does in the model because of the inertia of the fuel droplets. Similarity of the jet angle, therefore, should be added to the list of similarity criteria. With such corrections, model technique is a most powerful instrument for the furnace designer. W. Gumz, Germany

940. Baskakov, A. P., Complete combustion of coal dust (in Russian), *Trudl Ural'skogopolitekhn. In-ta* no. 61, 5–14, 1956; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10878.

Author carries out a study of the process of combustion of semi-dispersed coal dust. During combustion in the diffusional and kinetic zones simple exponential relations were obtained (confirmed by the results of experiments) for the determination of the amount of unburnt fuel in a period of time. The correlations obtained were found to be applicable when there were variations of both concentration and temperature. E. K. Chekalin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

941. Barnett, H. C., and Hibbard, R. R. (edited by), Basic considerations in the combustion of hydrocarbon fuels with air, NACA Rep. 1300, (9 papers), 259 pp., 1957.

942. Gill, G. S., Eckel, E. F., Williams, F. A., and Penner, S. S., Determination of rocket motor combustion parameters by means of a diverging reactor, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 712–724.

Measurements of longitudinal pressure distribution are reported for rocket motor comprising continuously diverging duct. Propellants were liquid oxygen and kerosene injected via impinging jets. Paper also reports theory permitting prediction of pressure distribution assuming one-dimensional single-phase flow. Solutions are given neglecting axial conduction and diffusion, and assuming one-step reaction of zero activation energy.

Interpretation of experimental data in light of theory suggests that in downstream region, where one-dimensional assumption is approximately valid, activation energy is high (30 k cal/mole). Activation energy only appears to be low (2 k cal/mole) near injector, where flow is two-phase and where conduction and diffusion are not negligible.

Readers may care to know that exact integrations for uniform-area motor have been published by Adler [*Aero. Res. Counc. Lond.* Paper 20,189]; this work accounts for chemical reaction of high activation energy, two-phase flow and droplet vaporisation.

D. B. Spalding, England

943. Brewster, H. M., and Kush, A., Development of a turbojet altitude windmill re-light correlation, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 705–71..

Correlation is in terms of an air parameter and a fuel parameter, both based on rational analysis of dimensionless groups of variables, with values of exponents obtained from two different engines using two different fuels. Method requires envelope separating re-light and no re-light regions to be determined experimentally for any particular engine, but correlated parameters then allow prediction under widely different windmilling conditions, including different hydrocarbon fuels, by use of an arbitrary "relative" vapor pressure calculation.

D. G. Shepherd, USA

944. Childs, J. H., Reynolds, T. W., and Graves, C. C., Relation of turbojet and ramjet combustion efficiency to second-order reaction kinetics and fundamental flame speed, NACA Rep. 1334, 13 pp., 1957.

945. Spalding, D. B., Analogue for high-intensity steady-flow combustion phenomena, *Instn. Mech. Engrs. Proc.* **171,** 10, 383–412, 1957.

946. Strauss, W. A., and Edse, R., Burning velocity measurements by the constant-pressure bomb method, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 377–385.

Method used by the authors to measure the burning velocities of gas mixtures is the well-known constant pressure bomb using a high-pressure chamber made of a 10-ft length of 12-in. pipe, together with two types of constant pressure bombs: (1) the non-aqueous soap solution bubble and (2) the transparent thin-walled balloon.

Results concern carbon monoxide-oxygen flames, carbon-monoxide-air and methane-air flames, methane-oxygen, hydrogen-oxygen and hydrogen-nitric-oxide flames.

Authors conclude that the effect of pressure on the burning velocities of premixed gas mixtures can be explained by the effect of pressure on the rate of diffusion of active radicals, on the rate of heat transfer from burned to unburned gas and, in cases where a chemical reaction is the rate-determining process, it can be explained by the effect of pressure on this chemical reaction. All these factors appear greatly interelated and the finding of an analytical expression for the burning velocity as a function of pressure over a large range of pressures appears extremely difficult.

R. Delbourgo, France

947. Cole, D. J., and Minkoff, G. J., Experimental techniques for the study of flat flames by infra-red spectroscopy, *Combustion and Flame* **1,** 2, 241–249, June 1957.

948. Toone, B., and Arkless, F., The application of gas analysis to combustion chamber development, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 929–937.

Describes rapid method of gas analysis for determining combustion efficiency of gas-turbine combustors. Uses infrared analyzers for CO and CO_2; differential thermal conductivity cell for H_2, with removal of interfering CO_2 with soda-lime; combustion in a catalytic furnace for unburned hydrocarbon fuel; paramagnetic force for O_2; and absorption in the near-infrared for smoke. Efficiency of combustor determined by adding losses attributed to each constituent determined by this analysis. Relative importance of each constituent shown to depend on range of combustion efficiency being obtained. Between 98.5 and 100 per cent efficiency, CO is worst offender; below 98.5 per cent, unburned fuel increases rapidly. Traverses of combustion chamber with gas-sampling probe provided information on fuel reaction velocities.

W. T. Reid, USA

949. Fristrom, R. M., Prescott, R., and Grunfelder, C., Flame zone studies III—Techniques for the determination of composition profiles of flame fronts, *Combustion and Flame* **1,** 1, 102–113, Mar. 1957.

Prime Movers and Propulsion Devices

(See also Revs. 942, 943, 944, 948, 970)

950. Nachbar, W., and Green, L., Jr., Analysis of a simplified model of solid propellant resonant burning, *J. Aero/Space Sci.* **26,** 8, 518–526, Aug. 1959.

Authors analyze a model of solid propellant burning in which the rate of burning of the solid propellant depends on an Arrhenius function of the propellant surface temperature. This temperature is, in turn, established by a balance between the heat transferred from the gaseous stream produced by combustion of the propellant on the one hand and absorbed by the decomposing propellant and conducted away through the solid, on the other. The heat-transfer process is represented by conduction through a film whose thickness is related to the rate of decomposition as well as hydrodynamic factors usually found in this type of approximation.

The resulting expressions are then linearized for small perturbations, and it is found that the surface temperature variation may become very large for a resonant frequency provided certain other conditions are met. Detailed discussion of the coefficients leads to suitable approximations for calculating the resonant frequencies from properties of the propellant.

An extension of the discussion indicates that the behavior of the conditions for resonance with changes in assumed properties of the propellant may be parallel to experience in the liability of propellants of various kinds to unstable combustion. Accordingly, authors suggest the desirability of experimental evaluation of certain propellant characteristics, including their steady-state burning properties.

M. A. Mayers, USA

951. Morley A. W., Notes on air breathing engines for supersonic flight, *J. Roy. Aero. Soc.* **63,** 577, 23–34, Jan. 1959.

952. Drake, J. F., and De Vault, R. T., Ramjet-powered supersonic transports, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-38, 8 pp.

953. Cumming, J. M., Rocket power for manned flight, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-65, 23 pp.

954. Kelley, A. P., A comparison of long-duration secondary-power schemes for space vehicles, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-39, 8 pp.

The status and limitations of seven basic schemes for converting solar or nuclear radiation to electricity are reviewed. The closed-heat engine cycle employing a hermetically sealed turbo-alternator is selected as the scheme offering the earliest availability for space power applications requiring above a few kilowatts of electrical power. Development problems of the small turbomachinery cycle are emphasized. The conclusion is made that development of the long-duration space power supply may be lagging behind vehicle launch capability.

From author's summary

955. Huth, J. H., Power for satellites, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-3, 4 pp.

956. Boden, R. H., Recent developments in ion propulsion systems for space travel, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-45, 32 pp.

A brief summary of recent developments in ion propulsion introduces a discussion of the ion rocket engine for controlling the altitude of a vehicle. Preliminary analyses of changing orbits in the neighborhood of the earth establish a method for correcting terminal orbits and establish requirements for the rocket engine. The selection of the specific impulse is made to obtain a high payload fraction. Comparison of chemical and ion rocket engine capabilities show that the two engine systems supplement each other. From author's summary

957. Kraemer, R. S., and Larson, V. R., Comparison of several propulsion systems for a Mars mission, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-46, 56 pp.

Propulsion energy requirements to place a payload in orbit about Mars are analyzed. Six typical space propulsion system designs to accomplish this mission are described and evaluated in terms of their relative payload capability.

From authors' summary

Symposium on engine testing, *Proc. Instn. Mech. Engrs.* **172**, 7, 245-300, 1958. (includes Discussion).

958. Freeston, H. G., Test bed installations and engine test equipment, 245-260.

Paper emphasizes internal-combustion-engine test installations for research purposes, and deals with engine mounting, provision of services, routine and specialized measurements, and controls. Information is up-to-date. Much ground is covered, but treatment is brief, descriptive and rather superficial.

P. M. Ku, USA

959. Laurence, R. A., and Collins, W. H. A., Type testing, 261-265.

960. Buckland, W. R., Statistical methods applied to engine testing, 266-277.

Paper is basically an introduction of the concept of statistics to internal-combustion engine testing, and is not concerned with analytical techniques. The three main sections deal with the interpretation of results from one group of tests, two groups of tests and many groups of tests. The subject of statistical design of experiments is also briefly discussed.

P. M. Ku, USA

Magneto-fluid-dynamics

(See also Revs. 691, 881)

961. Krzywoblocki, M. Z. v., and Martin, J. T., Canonical forms, Beltrami flows, and certain exact solutions in magneto-gas-dynamics, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Tex., Sept. 1959; Austin, Tex., Univ. Press, 1959, 427-445.

A flow of a diabatic inviscid, non-heat-conducting compressible fluid which possesses an electrical conductivity and a magnetic permeability is considered in an electromagnetic field. Authors derive the canonical forms of the equations for this kind of flow. The necessary conditions to have a Beltrami flow field or a generalized Beltrami flow are given. Solutions for certain plane flow (constant magnitude of velocity) are also derived.

G. Sestini, Italy

962. Pai, S. I., and Speth, A. I., The wave motions of small amplitude in radiation-electro-magneto-gas dynamics, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Tex., Sept. 1959; Austin, Tex., Univ. Press, 1959, 446-456.

Authors consider the wave motion of small amplitude in a plasma, including radiation phenomena which exert influence only on the longitudinal waves, which are characterized, together with the transverse waves, by the linearized fundamental equations. The interaction of the radiation effect with the Alfven wave is the same as that in ordinary magneto-gas-dynamics.

G. Sestini, Italy

963. Ludford, G. S. S., and Murray, J. D., Further results on the flow of a conducting fluid past a magnetized sphere, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Tex., Sept. 1959; Austin, Tex., Univ. Press, 457-465.

In a previous paper (submitted for publication) authors consider the steady flow of an incompressible, inviscid conducting fluid past a sphere of arbitrary conductivity containing an arbitrary symmetric magnetic distribution. The investigation was concerned with the first-order effects of the magnetic field and the conductivity of the fluid. In the present paper authors consider the general axially symmetric magnetic distribution in more detail.

It appears that the singularity in the vorticity can only be absent when the undisturbed magnetic field vanishes at the front stagnation point. Explicit formulas for the drag are given in terms of certain coefficients determined by the distribution.

From authors' summary by G. Sestini, Italy

964. Chang, C. C., and Yen, J. T., Rayleigh's problem in magnetohydrodynamics, *Physics of Fluids* **2**, 4, 393-403, July-Aug. 1959.

Extension of Rayleigh's problem to magnetohydrodynamics is investigated for a perfectly conducting plate with a transversely applied magnetic field. Induced electric and magnetic fields are both included in the analysis. Results obtained show that along the plate an electromagnetic body force will act in the direction of fluid motion. The results are found to be the same whether the applied magnetic field is fixed-in-space or attached to the moving plate. A comparison of these results with those of Rossow (magnetic field fixed with fluid) shows opposite trends in the velocity profile. Such discrepancies are discussed. Rossow's second case (magnetic field fixed with plate) is also discussed.

From authors' summary by S. Lampert, USA

965. Whitham, G. B., Some comments on wave propagation and shock wave structure with application to magnetohydrodynamics, *Comm. Pure Appl. Math.* **12**, 1, 113-158, Feb. 1959.

Author treats a general type of linear, hyperbolic, partial differential equation which is representative of approximate forms derivable from the nonlinear equations of hydraulics and hydromagnetics. Let $D(v)$ represent the operator $(\partial/\partial t + v\,\partial/\partial x)$ where v is a velocity; then the general linear equation considered can be rendered as $[D(c_1)\,D(c_2)\ldots D(c_n) + \lambda\,D(a_1)\,D(a_2)\ldots D(a_m)]\,\phi = 0$. For non-diverging solutions with the c's and a's all real and distinct, it is necessary that $m = n - 1$, $\lambda > 0$ and $c_1 > a_1 > c_2 > a_2 \ldots$

$a_{n-1} > c_n$. When $n = 2$, the lower-order term, i.e. that multiplied the coefficient λ, gives the basic wave motion on which is superposed a diffusion contributed by the higher-order terms. Conversely, the lower-order term gives rise to exponential damping of disturbances along the characteristics specified by the higher-order terms.

These results are obtained for special cases of the second-order linear equation, first by examining its simple harmonic wave solutions and then more generally by study of an arbitrary pulse. Linearized, approximate equations representing one-dimensional river flow provide an example illustrating the second-order theory. Connections are then made with the nonlinear equations of river flow via the method of characteristics and the use of the lowest-order approximations. Where solutions of the lowest-order set of equations break down, the situation may be saved, in a conventional manner, by the introduction of shock waves. The profile of the shock wave may be investigated by return to the full nonlinear equations under transformation to a new independent variable whose origin moves with the shock-wave velocity found from the lowest-order approximation.

Author then gives a detailed discussion of the one-dimensional hydromagnetic equations with non-zero conductivity, i.e., $\sigma \neq 0$, for small perturbations of the dependent variables. He first indicates that these perturbations each satisfy a fourth-order partial differential equation of the general type just given. Characteristics, characteristic velocities and solutions are discussed. By suitable approximations the facts are elicited concerning the main wave motion, its diffusion on account of higher-order terms, and the exponential damping of higher-order wave motions because of coupling with the lower-order terms. Reduced equations, which can be obtained by letting $\sigma \longrightarrow \infty$, are considered and a table given specifying the occurrence of a boundary layer when the number of boundary conditions in the full problem exceeds those needed to determine solutions of the reduced equations. Instructive x-t diagrams are presented to illustrate the various cases. When the nonlinear equations are considered no generalizations are possible. Author gives a condensed discussion which purports to show how the modifications introduced by nonlinearities affect the basic wave motions already identified in the linear cases. Finally, the hydromagnetic shock profile is investigated and discontinuities in the profile discussed. Author rederives a criterion, due to Marshal [*Proc. Roy. Soc. Lond.* (*A*) **233**, p. 367, 1955], for the appearance of profile discontinuities under the more stringent assumptions that viscosity and heat conduction may be neglected. Because of these assumptions, the shock profiles investigated cannot owe their existence to the usual causes, but must arise from the well-known wave-steepening properties associated with the fluid dynamical equations mediated only by the dissipative effects of the electrical resistivity of the medium. Sketches are given illustrating typical profiles with and without discontinuities. A critical note appended to the paper provides a correction to the most complex of these figures.

As title suggests, paper is informal and proofs are heuristic. Reviewer found the presentation very interesting and instructive but excessively long. Partly because of the rambling and repetitious style in which the paper is written, reviewer has been unable to gain a coherent impression of the possible new contributions made by the author. It seems fair to say that these lie more in the method of treatment and in the connections shown with a type of linear partial differential equation than in the absolute novelty of the results obtained. F. D. Bennett, USA

966. Rosenbluth, M. N., and Rostoker, N., Theoretical structure of plasma equations, *Physics of Fluids* **2**, 1, 23-30, Jan.-Feb. 1959.

Stability of a collisionless plasma under small perturbations from equilibrium is investigated by integration of the linearized Boltzmann equation for the perturbation distribution function along the unperturbed particle paths. The ratio λ of Larmor radius to a characteristic length L of the problem is assumed to be small and the following parameters are assumed to be of order λ: frequency of the disturbance/cyclotron frequency, frequency of the disturbance/plasma frequency, Debye length/L. Conditions for stability are derived and it is proved that they are equivalent to a variational statement about the energy perturbation W. It is shown that W is bounded below by the magnetohydrodynamic approximation and above by the approximation of Chew, Goldberger and Low.

H. G. Loos, USA

967. Ladyzhenskaia, O. A., and Solonnikov, V. A., On the solvability of nonstationary magnetohydrodynamic problems, *Doklady Akad. Nauk SSSR* (*N.S.*) **124**, 1, 26-28, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. L-124, 4 pp.)

Three boundary-initial-value problems for nonsteady, nonlinear magnetohydrodynamic equations are formulated. It is stated that the existence of solutions in the large of these problems can be proved within the class of velocity vectors and magnetic vectors which, together with their first derivatives (in a suitable generalized sense), are square integrable for each instant of time t.

Authors state that they have no uniqueness theorem for this class of solutions at present. However, if the solutions satisfy further smoothness conditions, uniqueness is available. They further mention that the existence of "smooth" definition can be proved for sufficiently small Reynolds number and small external forces.

A sequence of the formal steps used in the first existence proof (the method is that of orthogonal projection in suitable Hilbert spaces) of one of the three problems is outlined. No complete proofs or exact statements of the theorems appear in the paper.

S. Lampert, USA

968. Napolitano, L. G., On the surfaces of discontinuity in the magneto-fluid-dynamics (in Italian), *Aerotecnica* **38**, 4, 210-220, Aug. 1958.

The starting point is the equations of magneto-gas-dynamics consisting of the system of equations of classical gas dynamics and Maxwell's equations. The assumptions are: perfect gas, inviscous and non-heat-conducting, the motion is steady, the velocity much less than the velocity of light, the magnetic permeability of the fluid is constant and its electric conductivity, σ, is a function of the absolute temperature. After some transformations the system is reduced to a system of vectorial equations in six unknowns: p, ρ, T, $\vec{v}$, $\vec{H}$ (intensity of the magnetic field), $\vec{E}$ (intensity of the electric field). Next the author introduces the surface of the discontinuity, G, and a system of three curvilinear coordinates on G and in the direction normal to G. The system of equations is expressed in the new coordinate system and the electric field is assumed to possess no discontinuity. The problem is finally reduced to a system of eight equations, which express mathematically all the necessary conditions to be satisfied in the case of the existence of a discontinuity. Denoting by the symbol m the flux ρv_n (v_n = velocity component normal to G), author presents solutions in various cases, in which $m = 0$. Thus the solutions refer to flows with vortex surfaces of discontinuity and contact surfaces. The following cases are considered: (1) σ = constant; (2) $\sigma = \infty$; (3) $\sigma = \sigma(T)$. In (1) it appears that the vortex surfaces are possible provided that H_n (normal component) = 0. In (2) the properties of the discontinuity surface depend upon the geometry of the surface. In (3) the vortex surfaces are always possible. The existence of the contact surfaces implies the existence of a discontinuity in the magnetic field. M. Z. v. Krzywoblocki, USA

969. Agostinelli, C., Spherical vortexes in magnetohydrodynamics (in Italian), *Atti Accad. Naz. Lincei, R.C. Cl. Sci. Fis. Mat. Nat.* (8) **24**, 1, 35-42, Jan. 1958.

Author considers a homogeneous infinite incompressible inviscid fluid, with infinite electrical conductivity and subject to a uniform magnetic field H_0; H_0 is parallel to Cartesian axis Oz. Author assumes that symmetrically about Oz a spherical hydrodynamical vortex may occur whose kinetic characteristics are identical with that of known hydrodynamical Hill vortex; that the vortex center moves uniformly along Oz; that a new magnetic field H arises, having, as the velocity v of fluid particles, radial and axial components. All the components of H, v, and pressure p are explicitly calculated and are continuous through spherical vortex surface. At infinite distance $v \longrightarrow 0$, $H \longrightarrow H_0$, $p \longrightarrow p_0$ (p finite).

R. Nardini, Italy

970. Eckert, H. U., A cool mercury plasma tunnel, *J. Aero/Space Sci.* **26,** 8, 515–517, Aug. 1959.

Radio-frequency excitation of supersonic flow is discussed as a possible means to study effects of ionization at moderate temperatures. The heat of recombination counteracts liquefaction of the flow during expansion and permits the use of a vaporized liquid as testing medium. The flow can therefore be generated without pumps by an evaporation-condensation cycle. Mercury is selected as the most suitable medium. A small tunnel built upon these considerations is described. Author concludes that the combination of the two-phase driving system with radio-frequency heating has advantages for hypersonic and low-density tunnels.

W. M. Conn, USA

971. Shercliff, J. A., Axial current electro-magnetic flowmeters, *J. Nuclear Energy* 1B (*Reactor Technology*), 1, 3–9, Apr. 1959.

Electromagnetic flowmeters, in which measurable potential differences are induced in liquids flowing in pipes under transverse magnetic fields, are in wide use in nuclear reactors and elsewhere. Kolin has proposed another type of meter, in which a circular magnetic field is produced by an axial current flowing through liquid metal in the direction of flow. An emf, proportional to flow rate, is induced between the center of the pipe and the walls. In this paper, the characteristics of this, the current bearing liquid meter, are discussed. An alternative design, which may be termed the central conductor meter and which avoids some of the difficulties of the other axial current meter, is then discussed. Initial tests with mercury on a stainless-steel central conductor meter are described and are fairly promising. The main advantages claimed for these meters are insensitivity to upstream flow disturbances and to variation in liquid/solid contact resistance, and the feasibility of using the meters even when the pipe walls have to be ferromagnetic. From author's summary by A. H. Shapiro, USA

Aeroelasticity

(See also Rev. 671)

972. Brown, S. C., Predicted static aeroelastic effects on wings with supersonic leading edges and streamwise tips, NASA Memo 4-18-59A, 38 pp., Apr. 1959.

Chordwise and spanwise deflections are taken into account. Aerodynamic and structural forces are introduced in influence coefficient form; the former are developed from linearized supersonic wing theory. The predicted effects of flexibility on lateral-control effectiveness, damping-in-roll, and lift-curve slope are shown for a low-aspect-ratio wing at Mach numbers of 1.25 and 2.60. The control effectiveness is shown for a trailing-edge aileron, a tip aileron, and a slot-deflector spoiler located along the 0.70 chord line. The calculations indicate that the tip aileron is particularly attractive from an aeroelastic standpoint. The use of a modified strip theory gave adequate results only for the high Mach number case. Elimination of chordwise bending exaggerated the aeroelastic effects on rolling-moment and lift coefficients for both Mach numbers.

From author's summary by H. M. Voss, USA

973. Min-De, D., On the stability of elastic plates in a supersonic stream, *Soviet Phys.-Doklady* **3,** 3, 479–483, Jan. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **120,** 4, 726–729, May–June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Panel flutter of a two-dimensional supersonic plate is posed as an integro-differential equation. The complete solution is developed in terms of the characteristic roots of the homogeneous differential equation and a formal solution results by Laplace transformation and contour integration. No applications are given. H. M. Voss, USA

974. Hancock, G. J., Divergence of plate airfoils of low aspect ratio at supersonic speeds, *J. Aero/Space Sci.* **26,** 8, 495–507, 517, Aug. 1959.

Plate wings of uniform thickness, constant chord and variable sweep are treated. Aerodynamic forces are approximations of linearized supersonic theory. Spanwise deflection mode is assumed. Differential equation governing chordwise deflection mode for neutrally stable equilibrium is derived by calculus of variations.

Solutions establish that leading edge sweep increases stability. Critical conditions occur when leading edge is sonic for sweep less than 30°, and when $M = 1$ for sweep greater than 30°.

G. Isakson, USA

Aeronautics

(See also Revs. 654, 839, 846, 872, 882, 974)

975. Ludi, L. H., Flight investigation of effect of transition, landing approaches, partial-power vertical descents, and droop-stop pounding on the bending and torsional moments encountered by a helicopter rotor blade, NASA Memo 5-7-59L, 38 pp., May 1959.

Results of the investigation indicate that transition, landing approaches, partial-power vertical descents, and static droop-stop pounding produce large increases in the periodic blade moments. The results indicate that partial-power vertical descents and landing approaches produce rotor-blade moments that are higher than the moments encountered in any other flight condition investigated to date with this equipment.

From author's summary

976. Fischel, J., Butchart, S. P., Robinson, G. H., and Trement, R. A., Flight studies of problems pertinent to low-speed operation of jet transports, NASA Memo 3-1-59H, 21 pp., Apr. 1959.

The specific areas investigated include those of the take-off and landing, and relation of these maneuvers to the 1g stall speed and stalling characteristics. The take-off studies included evaluation of the factors affecting the take-off speed and attitude, including the effects of premature rotation and of overrotation on ground run required. The approach and landing studies pertained to such factors as: desirable lateral-directional damping characteristics; lateral-control requirements; space-positioning limitations during approach under VFR or IFR conditions and requirements for glide-path controls; and evaluation of factors affecting the pilot's choice of landing speeds.

Specific recommendations and some indication of desirable characteristics for the jet transports are advanced to alleviate possible operational difficulties or to improve operational performance in the low-speed range. From authors' summary

977. Butchart, S. P., Fischel, J., Tremant, R. A., and Robinson, G. H., Flight studies of problems pertinent to high-speed operation of jet transports, NASA Memo 3-2-59H, 17 pp., Apr. 1959.

Some of the specific areas investigated include: (1) an overall evaluation of longitudinal stability and control characteristics at transonic speeds, with an assessment of pitch-up characteristics, (2) the effect of buffeting on airplane operational speeds and maneuvering, (3) the desirable lateral-directional damping characteristics, (4) the desirable lateral-control characteristics, (5) an assessment of overspeed and speed-spread requirements, including the upset maneuver, and (6) an assessment of techniques and airplane characteristics for rapid descent and slowdown. The results presented include pilot's evaluation of the various problem areas and specific recommendations for possible improvement of jet-transport operations in the cruising speed range. From authors' summary

978. Grimes, C. K., Development of a method and instrumentation for evaluation of runway roughness effects on military aircraft, AGARD Rep. 119, 33 pp., May 1957.

A method for prediction of airplane response during taxiing over rough runways is developed. The techniques of generalized harmonic analysis are used to predict (a) number of occurrences of loads exceeding a specified magnitude, and (b) probability of exceeding a load of specified magnitude.

The method developed is applicable to design for fatigue aspects as well as for criticality of loads developed during taxiing.

Instrumentation is developed to facilitate recording of runway profiles. Reduction of data recorded on magnetic tape to runway power spectra is accomplished by a high-speed digital computer. Data handling during reduction is minimized.

Application of the methodology and instrumentation to determine dynamic response of any surface vehicle is possible. In addition, design and maintenance of airfield surfaces and public roads may be facilitated by proper application of the techniques developed during this study. From author's summary

979. Stevens, J. E., Relaxation characteristics of pneumatic tires, *J. Aero/Space Sci.* **26,** 6, 343–350, June 1959.

A simplified model of an elastic tire is assumed and is used to derive equations for the relaxation and cornering behavior of rolling tires and for tire lateral stiffness, torsional stiffness and cornering power. Resulting theoretical predictions are in fair agreement with the trends of experimental data.

R. F. Smiley, USA

980. Bain, R. W., Leslie, D. C. M., Ruston, Miss G. C. A., and Hynd, W. R. B., Statistical analysis of a particular target manoeuvre, *Aero. Res. Counc. Lond. Curr. Pap.* 423, 20 pp., 1959.

A novel form of random maneuver is proposed and analyzed to determine the correlation functions describing the statistical properties of the velocity and displacement of the maneuvering target. Maneuver consists of moving along one of three parallel paths, and switching at random from one path to the next—with the center path as the desired course. Using generalized harmonic analysis of random sequences, the results are given as the autocorrelations of the lateral velocity and displacement and the cross-correlation between these.

Reviewer believes the results are correct and interesting—particularly as indications of the characteristics of the class of maneuvers discussed. L. A. Gould, USA

Astronautics

(See also Revs. 883, 954, 956, 957)

981. Berger, W. J., and Ricupito, J. R., Prediction theory of missile and satellite orbits, *ARS J.* **29,** 6, 428–432, June 1959.

Starting with the vector form of the equations of motion in a central inverse-square field

$$\bar{H} = \bar{R} \times \dot{\bar{R}}$$

$$\bar{B} = \bar{H} \times \dot{\bar{R}} + \mu \bar{R}/|\bar{R}|,$$

author derives expressions for orbital parameters in terms of the constants $\bar{H}$ and $\bar{B}$. Assuming that a tracking radar gives all six components of position and velocity at each observation instant (which present installations usually do not, contrary to authors' assertion), it is possible to use above equation to determine a value of $\bar{H}$ and $\bar{B}$ at each time point. The trajectory parameters are then computed from the time-averaged values of $\bar{H}$ and $\bar{B}$.

To test whether the observations represent a ballistic path, authors assert "a necessary and sufficient condition for existence of a gravitational orbit" is that $|\dot{\bar{B}}_I| < |\dot{\bar{R}}_I|$ in which the subscript I denotes unit vector. Authors' argument does not convince reviewer of either necessity or sufficiency. J. Lorell, USA

982. Munick, H., An optimum transfer path from an elliptical orbit to a higher energy circular orbit, *ARS J.* **29,** 6, 449–451 (Tech. Notes), June 1959.

Author attempts to show that the two-impulse minimum energy transfer from perigee of an elliptic orbit to a circular orbit of higher total energy is achieved by the Hohmann ellipse starting at the circular orbit through perigee. His argument is valid provided the high energy circular orbit does not intersect the initial elliptic orbit. In this case, Eq. [7] does not hold, but must be replaced by the equation

$$|-|\Delta\vec{v}_P| + |\Delta\vec{F}|]_{\text{HOHMANN}} = |\Delta\vec{v}_{OPT}| + |\Delta\vec{F}_{OPT}| - |\vec{y}|$$

which the author does not discuss. Whether or not the expression on the left actually represents a minimum remains to be shown.

J. Lorell, USA

983. Vinti, J. P., Theory of the effect of drag on the orbital inclination of an earth satellite, *J. Res. Nat. Bur. Stands.* **62,** 2, 79–88, Feb. 1959.

For an atmosphere which is assumed to rotate with Earth as a rigid body, the change of orbital inclination is determined for two stages of motion. The first is that of precessing and shrinking ellipses, this is assumed to last more than a year. The second stage is a quasi-steady spiral motion. The third stage, the ballistic re-entry, is not treated in the paper. Author starts out with a very general drag function which later on drops out from the solution.

The complicated result is illustrated on an example whereby a satellite having an initial apogee of 2000 mi. and perigee of 400 mi. drops in the first stage to 200 mi. The change of orbital inclination is shown to be $-0.173 \sin \theta_0$ degree if θ_0, the initial angle, is not close to a critical value of 63.4°. During the second stage the satellite drops to 100 mi. and the accompanying inclination change is $-0.022 \sin \theta_0$ degree. The total change for any θ_0, even for 63.4°, will be less than 0.368°.

G. S. Gedeon, USA

984. Platonov, A. K., Selection of the parameters for high-altitude several-stage missiles (in Russian), *Trudi Mosk. Aviats. In-ta* no. 64, 15–40, 1956; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7533.

An approximate graphical analysis method is set forth for determining the planned parameters for single-stage and two-stage high-altitude missiles. The ballistic problem is solved for the

case of vertical flight, without allowing for the atmosphere, in dimensionless parameters, and a method is given for plotting a network of relationships between the dimensionless parameters of motion and the similarity criteria of missiles (relative mass and thrust-weight ratio). Using this graph, author solves the ballistic problem (for the preliminary stage of missile design) of determining the required relative finite mass for a certain ceiling, thrust-weight ratio and specific thrust. A plan for an analogous solution of the ballistic problem for flight in the atmosphere is indicated, with approximate allowance for the forces of drag and the influence of the counter-pressure of the air on the motor characteristics. An equation is compiled for the weight balance of a missile, using statistical data on the specific gravimetric characteristics of structural parts with the exception of motor parts which are made the subject of approximate theoretical gravimetric analysis. A procedure for determining the basic design parameters of missiles is developed which uses the method set forth for solving the ballistic problem. In this procedure the optimum parameters are incompletely selected. The minimum total fuel consumption is selected as the criterion of perfection. The optimum pressures in the motor chamber and at the nozzle are selected for a single-stage missile from this condition. The optimum coefficient of excess of oxidizing constituent is only determined for the maximum thermodynamic specific thrust. The question of selecting the optimum staging technique is examined for two-stage rockets. A method of graphical detection of the optimum combination of values for the relative finite masses of the stages, according to the condition of minimum fuel consumptions, is developed. The problem is solved for the case of the two stages having identical specific motor thrusts and different gravimetric coefficients. A. S. Budnik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Acoustics

Book—985. Matauschek, J., Introduction to the technology of ultrasonics (Einführung in die Ultraschalltechnik), Berlin, VEB Verlag Technik, 1957, 535 pp. DM 36.

This is a very valuable addition to the small number of books on ultrasonics. It fills a gap between a number of existing books with a limited scope and the comprehensive monograph by L. Bergmann. The titles of the main sections are:

(A) The physics of ultrasonics: the sound; the specific properties and the effects of ultrasonics.

(B) The techniques of ultrasonics: Mechanical generation of ultrasonics; Theory of ultrasonic generators using electro-mechanically active materials; Electrical generation of ultrasonics; Receivers and measuring techniques; Optics of ultrasonics.

(C) The applications of ultrasonics.

Every author of a publication that, in the first place, is planned for the engineer is faced with the question how far he should go in theoretical considerations. He eventually arrives at some compromise. In the present book a good compromise has been found in general, although undoubtedly every reader will have a somewhat different need for derivations and a different interest in basic equations. While derivations are held to a minimum or are only referred to, the final equations needed for computations of ultrasonic problems are given comprehensively and are, in many instances, supplemented by numerical examples that should make the book even more readable to the engineer with a restricted knowledge in the field.

The selection of the material is outstanding and a quite complete coverage of the present state of the art has been accomplished. Particularly interesting is the great number of applications described and critically analyzed. The following fields are covered: Underwater signals and navigation; Testing of materials; Metallurgy; Soldering of aluminum; Cleaning; Erosion; Food, textile, paper and chemical industry; Prevention of boiler scale; Gas purifying; Atomization of fuels; Biology, pharmacy and medicine.

It is unfortunate that mainly European manufacturers are quoted in the discussions of commercial ultrasonic equipment.

Reviewer was most favorably impressed by the fact that the "Kalantroff-Giorgi" system of units is exclusively used in the book. This system, which is based on the units meter, second, volt and ampere, is identical with so-called "absolute international system" based on meter, kilogram mass and second if the permeability of the vacuum is properly defined. Both systems are strikingly simple and convenient and at last eliminate the difficulties of the older systems that always included units that did not suggest a physical meaning (e.g., electrical units in the C.G.S. system!). It is hoped that the new systems, which are actually only one system, will be used soon in all technical literature.

More than seven hundred selected references give the reader the possibility for extensive studies. Tables and pictures supplement the text competently. The book should be of great benefit to the engineer but should also be well adapted to the college student of the graduate level.

Print, paper and binding are good. In spite of an Errata of about 10 items, a careful check of remaining errors is recommended before a second edition, e.g., the page numbers in the List of Contents are not always correct.

It is hoped that an English translation of this excellent book will be available soon, to which the reviewer would like to see an Appendix with a brief description of the most important American commercial equipment. H. J. Ramm, USA

986. Subba Rao, K., and Ramachandra Rao, B., Study of temperature variation of ultrasonic velocities in some organic liquids by modified fixed-path interferometer method, *J. Acoust. Soc. Amer.* **31**, 4, 439–441, Apr. 1959.

A simple, rapid and accurate method of determining temperature coefficient of ultrasonic velocity in liquids is presented. The method is based on a modification of the fixed-path double-crystal interferometer. Temperature variation of ultrasonic velocity in a few organic liquids has been studied by employing this method.

From authors' summary

987. Boucher, R., Contribution to the study of airborne ultrasound: Production and applications (in French), *Publ. Scient. Tech. Min. Air, France, Notes Tech.* no. 79, 138 pp., Dec. 1958.

Detailed study of theory and performance of various generators for production of high-intensity airborne ultrasound and application to precipitation of liquid and solid aerosols.

Experiments with artificial fogs in 2650 m^3 chamber confirm theory of Brandt and Hiedemann which predicts one or more optimum frequencies for each type. For example, with 2 acoustic watts/m^3 at 10 kc the visibility is doubled in 1 or 2 min for fog having 1 or 2 g/cm^3 of particles of mean diameter 5 μ.

Authors achieved 84 to 94% smoke precipitation with combined centrifugal and acoustic techniques using 3.9 to 7.5 kw per 1000 m^3/hr at flow rates of 300 to 600 m^3/hr. Particle concentration varied from 250 mg/m^3 to 2.8 g/m^3 and 70% (by weight) of particles were smaller than 1μ. Authors claim complex spectrum is better than simple one, and introduction of small amount of fog is beneficial. M. Greenspan, USA

988. Adkhamov, A., The propagation of ultrasonics in a medium consisting of neutral particles (in Russian), *Uch. Zap. Tadzh. In-ta* **10**, 125–132, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7445.

The collective interaction method developed by A. A. Vlasov is applied to the problems concerning the propagation of ultrasonics in medium consisting of neutral particles. Starting from the Vlasov

kinetic equation, author deduces hydrodynamic equations. These equations are linearized on the assumption that the state of the medium varies little in an ultrasonic wave. A one-dimensional problem, for which the wave propagation rate can be found, is examined; in the case of the simplest exponential law for short-range forces of repulsion

$$K(r) = \frac{g}{r} e^{-xr},$$

where g and x are certain constant molecular interaction parameters, and r is the distance, the following equation is obtained for the square of the ultrasonic velocity:

$$C^2 = \frac{5RT}{3M} + \frac{4\pi g}{x^2} d \left(\frac{N_a}{M}\right)^2$$

where $d = mp$ – the density, N_a is Avogadro's number, M is the molecular weight, and R is the gas content. For helium, $g = 2.3 \times 10^{10}$ erg cm, and $x = 3.32 \times 10^8 \text{cm}^{-1}$. Assuming that g and x depend little on the nature of the substance, and using the values given for them, a theoretical value of C can be obtained for various liquids. For example, for acetone $C = 1527$ m/sec, and for benzene $C = 1202$ m/sec at $T = 300$ K, while the experimental figures are equal to 1190 and 1324 m/sec, respectively. Thus the calculated and experimental figures agree satisfactorily. When deriving a more accurate equation for C, the density correlation in the adjoining volumes is taken into account. The use of the equations obtained for C in condensed mediums is confined to systems in which the forces of repulsion are stronger than those of attraction. The author notes that the equations obtained for velocity relate to gases rather than to liquids. V. A. Krasil'nikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

989. Vereshchagin, L. F., Semerchan, A. A., Maslennikov, M. V., and Sekoyan, S. S., The problem of the friction between a jet of water at ultrasonic velocity and the wall of a nozzle (in Russian), *Zh. Tekh. Fiz.* **27**, 7, 1589–1590, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7716.

An attempt is made to determine experimentally the relationship of the friction between an ultrasonic jet of water and the wall of a nozzle to the diameter and pressure before the nozzle. The friction was gaged by the temperature of the water collected in a vessel after flowing through the nozzle. It proved that the losses due to friction against the wall of a nozzle may be disregarded where the diameter exceeds 1.25 mm and the pressure is less than 700 atm. O. S. Vorob'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

990. Muller, E.-A., and Matschat, K. R., The scattering of sound by a single vortex and by turbulence, AFOSR TN 59-337 (Mitt. Max Planck Inst. Stromungsforschung Tech. Rep.; ASTIA AD 213 658), 30 pp., Jan. 1959.

As an elementary model for scattering of sound by turbulence, the scattering of a plane sound wave as it passes through a single vortex of finite radius is investigated. The phase surfaces of the scattered sound waves are conical. For small vortex radii and for normal incidence the intensity distribution is that of a cylindrical quadruple; for great radii, extreme forward scattering occurs.

The results of the single-vortex theory are applied to scattering by turbulence. The total scattering power turns out to be proportional to the 5th or 2nd power of the frequency of the incident sound wave, depending on whether the frequency is low or high. The theoretical predictions are well confirmed by the measurements. The results are applied to scattering by atmospheric turbulence. From authors' summary by M. S. Weinstein, USA

991. Lapin, A. D., Scattering of sound waves in irregular waveguides, *Soviet Phys.-Acoustics* **4**, 3, 272–279, Dec. 1958. (Translation of *Akust. Zh.* **4**, 3, 267–274, July–Sept. 1958 by Amer. Inst. Phys., New York, N. Y.)

Author considers the propagation of normal waves in a two-dimensional planar waveguide with rigid walls. Two cases are considered: The walls are smooth but the index of refraction has small spatial fluctuations, and (2) the medium is uniform but the walls are rough. The mean square amplitude of the normal waves is found in terms of the mean square value and the spatial consideration of the index of refraction. This is a valuable contribution to atmospheric and undersea sound propagation.

M. Harrison, USA

992. Lysanov, Iu. P., On the scattering of sound by a non-uniform surface, *Soviet Phys.-Acoustics* **4**, 1, 45–49, Oct. 1958. (Translation of *Akust. Zh.* **4**, 1, 47–50, Jan./Mar. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author provides an analysis of the reflection of normal incidence sound waves from a plane surface having a periodically varying admittance. The analytical technique (which the reviewer believes is new) can be used for surfaces with arbitrarily large deviations of the admittance from the mean value. The amplitudes of the specular reflected wave and the nonspecular scattered waves are determined from a finite set of algebraic equations whose number is determined by the parameters of the problem and the desired accuracy. Reviewer believes that the technique has application to problems of sound waves in rooms and sound waves propagating over the ground. However, the analysis is limited to the normal angle of incidence and to periodically varying boundary properties. No experimental data are given in the paper.

I. Dyer, USA

993. Liamshev, L. M., Sound diffraction by an unbounded thin elastic cylindrical shell, *Soviet Phys.-Acoustics* **4**, 2, 161–167, Dec. 1958. (Translation of *Akust. Zh.* **4**, 2, 161–167, Apr.–June 1958 by Amer. Inst. Phys., New York, N. Y.)

The oblique scattering of plane acoustic waves by an infinitely long thin elastic cylindrical shell of circular cross section is studied. If Fourier analysis with respect to the azimuthal angle is used, then the pressure at any point in the sound field can be obtained explicitly in the form of an infinite series. The results are briefly discussed, and some computations are presented. For a more detailed exposition the reader is referred to: "Sound scattering by a thin, unbounded cylindrical shell," Report of the Acoustics Institute, Academy of Sciences, SSSR, Moscow, 1956.

F. Ursell, England

994. Kanevskii, I. I., and Rozenberg, L. D., The calculation of the acoustical field in the focal region of a cylindrical focussing system (in Russian), *Akust. Zh.* **3**, 1, 46–61, 1957; *Ref. Zh. Mekh.* no. 7, 1958; Rev. 7444.

The field of an ultrasonic cylindrical concentrator in the focal region is calculated for an infinite cylindrical front, and also for a front of finite length. It was assumed for calculation purposes that part of the inner surface of a straight circular cylinder was the emitting surface. The problem is solved by a Kirchhoff approximation: the length of the wave emitted is considered to be small by comparison with the linear dimensions of the system. Certain sectors of the cylindrical surface may therefore be regarded as plane. The influence of diffraction on the rims of the cylinder is ignored. Close to the axis of the focussing system the field is computed by resolving the plane wave into series in terms of Bessel functions. The crossing method is used in the region further from the axis. The calculation shows that in the focal region there are regular potential zeros, while in the axial plane there are minima, not reaching zero, of potential. At small ex-

posure angles the half-width a of the focal band is given by the equation $a = 0.5\ f\lambda/b$, where f is the radius of curvature of the emitter, b is its half-width, and λ is the wavelength. Calculation of the finite length shows that the effect of the ends of an emitter on the distribution of potential in the focal region is small.

P. D. Rozenberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Micromeritics

(See also Revs. 757, 939, 1002)

Book—995. Faith, W. L., Air pollution control, New York, John Wiley & Sons, Inc., 1959, vii + 259 pp. $8.50.

A concise presentation of the important aspects of air pollution: its effects, influence of weather on it, methods of measuring air contaminants, applicable control methods, and legal problems related to it. Chapter headings are: (1) The air pollution problem, 29 pp.; (2) Meteorology, 20 pp.; (3) Smoke, 39 pp.; (4) Dusts, fumes, and mists, 42 pp.; (5) Gases, 37 pp.; (6) Odors, 9 pp.; (7) Automobile exhaust, 37 pp.; (8) The air pollution survey, 13 pp.; (9) Legal aspects, 11 pp. An appendix lists conversion factors for air pollution measurements.

Within this framework are discussed several air-pollution disasters; deleterious effects on human health and comfort, on property, and on vegetation; meteorological factors favoring air pollution; smoke as the most important factor; the smoke-producing characteristics of solid, liquid, and gaseous fuels and their combustion equipment; size range, chemical composition, and concentration of particulate contaminants; dust-fall rates in various cities; methods and devices for sampling and measurement, such as filters, cascade impactor, cyclone separator, thermal precipitator, particle-size analyzers; radioactive particles; gaseous contaminants, such as sulfur dioxide, hydrogen sulfide, hydrogen fluoride, chlorine and halogenated compounds; methods for analysis and for abatement; sources and measurement of odors; automotive exhaust characteristics with various fuels and at various operating conditions, their composition and abatement; afterburners and catalytic converters; testing and control procedures; planning and execution of an air pollution survey; legislation and regulation for air pollution control and enforcement.

This book is a useful and authoritative source of up-to-date information for civic betterment groups and industrial management interested in combating air pollution.

K. J. DeJuhasz, USA

996. Zverev, N. I., Modelling the motion of poly-dispersed material (in a fluid stream) (in Russian), *Teplo energetika* no. 7, 35–38, 1957.

Five dimensionless criteria are given describing a system with monodispersed material: (1) Reynolds number based on the equipment diameter; (2) Reynolds number based on the particle diameter but using the fluid velocity; (3) Froude number for the equipment; (4) particle concentration; and (5) a criterion given by the product of the ratio of the apparent density of the particles to the fluid density and of the ratio of the particle diameter to the characteristic equipment dimension. It is proved that in the case of polydispersed material these criteria are still suitable if the particle diameter is replaced by a suitable dimension of the polydispersed material. The cumulative particle distribution curve is important in defining this dimension. In order to have complete similarity of the model and full-scale unit, all five numbers must be equal and the cumulative curves of the two materials must also be similar (i.e. these curves must become identical when plotted against the particle diameter divided by the characteristic dimension of the given material).

Complete similarity is difficult and frequently impossible of attainment. Analysis of the problem shows that it is frequently possible to decrease the number of these criteria. If the concentration of the dust in the gas is from 0.05 to 0.1 kg/kg max (frequently fulfilled), the fourth criterion drops out. The gas flow often lies in the automodelling region (gas friction factor independent of equipment Re), when the first number falls out. If it is possible to neglect the effect of gravity, the third criterion can also be ignored. If, further, the Reynolds number for the particles is less than one (first automodelling region), only the Stokes criterion and the cumulative curve are necessary. If the particle Re is greater than 1000 (second automodelling region), the fifth number and the cumulative curve are adequate.

If three criteria remain from the original five, the modelling is difficult since it is possible to choose arbitrarily only three from the six dimensional quantities. It is indicated how a suitable polydispersed material can be prepared for the model in order to have a satisfactory cumulative distribution curve.

G. Standart, Czechoslovakia

997. Abduranpov, R., An experimental investigation of the silting of the 'lower water' of an original hydroassembly by deposits (in Russian), Avtorefer. Diss. Kand. Tekhn. Nauk, In-ta Vodn-problem i Gidrotekhn. Akad. Nauk UzSSR, Tashkent, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4149.

998. Klimentov, A. N., Hydraulic radius and Reynolds number of a silt flow (in Russian), *Gidrotekh. Stroit.* **24,** 4, 33–35, 1955.

999. Klimentov, A. N., Volumetric and actual specific weight of silt (pulp) (in Russian), *Gidrotekh. Stroit.* **22,** 11, 29–32, 1953.

1000. Finn, R., and Noll, W., On the uniqueness and non-existence of Stokes flows (in English), *Arch. Rational Mech. Anal.* **1,** 2, 97–106, Sept. 1957.

Porous Media

(See also Rev. 1012)

1001. Hammad, H. Y., Seepage losses from irrigation canals, *Proc. Amer. Soc. Civ. Engrs.* **85,** EM 2 (*J. Engng. Mech. Div.*) 31–36, Apr. 1959.

The problem of steady seepage from a canal through a stratum of low permeability to an underlying stratum of gravel where there is a piezometric head only slightly less than the canal water surface is solved by a transformation to allow rapid estimation of the flow by use of a table of elliptic functions. Simple and rapid solutions result. The assumptions are the usual ones.

K. N. Hendrickson, USA

1002. Scheidegger, A. E., Statistical approach to miscible displacement in porous media, *Canadian Mining and Metallurgical Bull.* **52,** 561, 26–30, Jan. 1959.

Author surveys tools available for dealing with problem of displacement of fluids from porous media by others which are miscible therewith. Due to complexity of boundary conditions recourse must be had to models. The developments leading to statistical models are sketched and an outline is given of the requirements in any statistical model. Theories are compared with experimental results as far as the latter are available.

From author's summary by J. C. Geyer, USA

1003. Motyakov, V. I., Construction of networks of flow of incompressible liquids for multilinked heterogeneous regions (in Azerb.), *Izv. Akad. Nauk AzerbSSR* no. 3, 19–37, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5598.

Three examples are given of the construction on an electric circuit model of plane filtration flows in multilinked heterogeneous regions. In order to obtain the current's circuit lines author cuts up the given region into subordinate single-link regions and finds on new models of these regions the lines of current as equipotential lines. The lines of the sections coinciding with some of the lines of the current are determined by graphical means as orthogonal trajectories to the equipotential lines, preliminarily found in the given region. The theoretical part of the paper contains the known situation in the theory of functions of a complex variable. In the examples given the angular points and the disruption of the orthogonal networks along the lines of change of the filtration coefficient are erroneously omitted. Author does not refer to the fact that the application of the method is connected with the error involved in determining by graphical means the lines of the sections; ordinarily these lines assume a more precise value by means of successive approximations; if this is done there appears to be no need to cut up the initial region into separate regions [see: for instance, Branfield and others, *Proc. Roy. Soc.* (*A*) **159**, p. 898, 1937].

G. Yu. Stepanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1004. Kogan, L. G., and Rozenberg, M. D., Flow of gasified petroleum when variations in saturation are small (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 10, 303–311, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5603.

A linearization of a system of equations for the transient motion of gasified petroleum is carried out to cover a more general case than that investigated earlier in the paper by M. D. Rozenberg [*Trudi Vses. Neftegaz. N.-i. In-ta* no. 6, 230–239, 1954]. As a result, the system is brought into the equation for heat conductivity; concepts are put forward for modelling the solutions of the equations obtained on an electro-integrator, designed for the solution of problems in the elastic regime. For the special case of the flow in a semi-infinite layer, investigated by Rozenberg previously, new more precise comparisons are put forward for the solutions of the linearized equations as against the nonlinear solutions.. There is a misprint in equations [4] of the article: in the square brackets in the second of these equations the reference should be to the product and not to the sum of the two terms.

V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1005. Filchakov, P. F., The method of successive, conformal transformations and its application in filtration problems. II; Case of the arbitrary hydrostatic pressure front (in Russian), *Ukr. Mat. Zh.* **8**, 1, 76–91, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2010.

An analysis of the conformal representation of a semiplane with a cutout isosceles triangle or a semiplane with an added isosceles triangle on the semiplane (representation *T*). Such a representation *T*, repeated several times together with the representation *E* (of a semiplane with an elliptical cutout in the semiplane), is used, in one example, for the conformal transformation of a filtering region for the case of a flat-bottomed channel with two absolutely-impermeable side walls of unequal length, for a pressure front represented by a rectilinear broken line to a filtration region with a flat bottom and a horizontal pressure front. Comparison of the analytical results with those obtained by electrical analogs (using six different kinds of electrically-conducting paper) showed that the divergence between the two sets of values falls within the limits of experimental accuracy. Several misprints have been observed.

(For Part I see AMR **11**(1958), Rev. 4796.)

S. N. Numerov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1006. Filchakov, P. F., The method of successive conformal transformations and its application to filtration problems. III; The case of close-spaced walls; bed filtration; filtration in anisotropic ground (in Russian), *Ukr. Mat. Zh.* **8**, 3, 299–318; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2011.

An examination of the conformal representation of a semiplane with an infinitely-narrow, rectilinear cut proceeding from the material axis of the semiplane at an arbitrary angle thereto, on a second semiplane ("*N*"-representation). This *N*-representation, repeated successively several times, is applied to the approximate analysis of the following three cases of established filtration according to Darcy's law: (1) The case of two-dimensional filtration founded on a flat stream bed with two symmetrical walls, in the presence of a homogeneous, permeable foundation of infinite depth, on the assumption that the distance between the side-walls is 0.8 of their length; (2) The case of plane filtration under natural head diverging around a bank abutment with an oblique spur; (3) The case of two-dimensional filtration in a homogeneously anisotropic, flat stream bed with two asymmetrical side walls, in the presence of a permeable foundation of finite depth. Comparison of the results of approximate analyses with the results of calculation by the rigorous method (Case 1), as well as the experimental results by the EGDA (analog) method using electrically-conductive papers (for cases 2 and 3), has shown that the approximate analyses are sufficiently accurate for use in ordinary engineering calculations.

S. N. Numerov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 861, 905, 1001)

1007. Bogdanoff, J. L., and Goldberg, J. E., On the transient behavior of a system under a random disturbance, Proc. Fourth Midwest. Conf. Solid Mech. Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 488–496.

Paper criticizes a former paper by Eringen in which the response of a building due to an earthquake is investigated by aid of a completely random disturbance. Present authors remark that the transient response is of importance so that random function should be nonstationary in time. This means that the variance of the disturbance should be zero for $t < 0$, increase gradually to a finite maximum and then fall again to zero as time increases. The white noise disturbance assumed by Eringen has infinite variance and, moreover, gives no transient response.

A. I. van de Vooren, Holland

1008. Malinovskaya, L. N., Analytical procedure for determining the dynamic properties of some seismic waves (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, In-ta Fiz. Zemlya, Akad. Nauk SSSR, Moscow, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4504.

1009. Smith, W. E. T., Bibliography of seismology, 22, Jan.–June 1957, 29 pp.; Ottawa, Canada, Department of Mines and Tech. Surveys, Dominion Observatory Publ., 1958.

Book—1010. Ihrig, D., editor, Report on the activities of the Research Institute for Water Resources in 1957 [Beszamolo a vizgazdalkodasi tudomanyos kutato intezet 1957], Pudapest, Muszaki Konyvkiado, 1959, 356 pp.

Hungarian Institute for Water Resources presents its annual report with a list of 27 topics and 57 new publications. Its contents: Papers on hydrology and hydrometry: K. Ubell, Observed pan evaporation; Z. Lászlóffy, Low flow investigations; T. Puskás and Ö. Starosolszky, Improved flumes for flow measurements; L. Muszkalay, Comparison of current meters; Z. Szigyártó, Influence of turbulence on current meter performance; K. Fazekas, Sewage metering equipment. Papers on practical hydraulics: K. Szesztay, Daily forecasting for Danube; D. Ihrig and K. Ubell, Seepage under levees; Z. Károlyi, Survey of the Danube flood plain; I. Zsuffa, Long-range forecasts for rivers; Gy. Szilágyi, Hydrologic investigation of irrigation; L. Szebellédy, Chemical weed control in drainage canals; I. Vágás, Effects of backwater on groundwater; L. Ivicsics, Silting in the East Main Canal.

Papers on water quality and sewage technology: L. Szebellédy, Qualification of water for irrigation; L. P. Szabó, Biological treatment of phenolic waste; P. Pásztó, Rapid digestion of refinery waste; J. Lesenyei and I. Tookos, Neutralisation of acidic waste. Papers on scale-model testing: J. Bogárdi, River models with movable bed and sediment movement; E. Varrók, Determination of pressure lines under levees; O. Haszpra, Laboratory investigation of measuring devices for irrigation; O. Györke, Scale-model investigation of a cooling pond.

Short summaries in one of four foreign languages conclude the volume. Many papers deserve detailed reviews. The annual report shows a high level of scientific research work in Hungary.

S. Kolupaila, USA

1011. Kutateladze, N. G., Investigation of a new type of ground reservoir—sand trap for mountain rivers (in Russian), *Trudī Gruz. Politekhn. In-ta* no. 2 (50), 13–28, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6666.

A description is given of laboratory investigations of a water reservoir of the type of water-collector proposed by G. A. Dzhimsheli. The principle underlying the action of the water reservoir consists in breaking down the layers of the flow saturated with silt in the vertical dissection and the separation of the top clean layers of water. The dam represents in itself a spillway with a wide threshold, within which are arranged water-collecting and settling galleries fitted with openings. A study was made on an experimental scale of the hydraulic and silting regimes of the construction and of its through-put capacity. The investigations showed the efficient work of the water-collector with periodic settling of the silt without interruption of delivery of water into the source. The values of the coefficient of discharge of the grid were obtained from the experiments, as well as the magnitude of depth of the water at the beginning and the end of the sluice, expressed through the critical depths. The water reservoir is recommended for water collection up to 6 m³/sec.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1012. Hunt, J. N., On the damping of gravity waves propagated over a permeable surface, *J. Geophys. Res.* **64,** 4, 437–442, Apr. 1959.

Author combines the linearized viscous flow theory (see for instance Lamb or Piesel) with the linear Reid and Kajiura equations for permeable medium. Satisfying boundary conditions leads to a solution for wave damping which for small values of viscosity and permeability turns out to be the sum of the above-mentioned two solutions. The wave period is found to be slightly greater than given by the classical solution—to the same order of approximation. Comparison with experiments is discussed.

Reviewer readily agrees with author's concluding remarks regarding the unsatisfactory state of knowledge on wave dissipation processes in general.

V. G. Szebehely, USA

1013. Nikiforov, E. C., The connection between a wind current and wind waves (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1450–1460, 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6705.

Attention is drawn to the necessity for investigating wind waves and wind currents as a single process, developing in the subsurface layer of the sea as the result of wind action. In author's view, the wind's energy, required for the development of wind waves as well as for wind currents, is imparted to the subsurface layer of the sea in accordance with a scheme proposed by Jefrison, P. L. Kapitsa and V. V. Shuleikin. A new model for wave motion of finite amplitude, in which the pressure along the wave profile is variable, is examined. Stokes's formula is obtained from the analysis of this model; this formula determines the velocity of the subsurface wave current through the wave elements. In author's opinion this current represents also the wind current. To substantiate this conclusion author has recourse to Eckman's formula, representing one side of his arguments; this formula links linearly the velocity of the wind current with velocity of the wind. On the other side, author uses ocular data of observations on wave motion in the ocean, collected by Khintertan, at various wind speeds from 1 to 10 points. The velocity of the wave current calculated by Khintertan's data for different wind velocities turned out to be close to the velocity of the wind current calculated by Eckman's formula; in the latter case a multiplicand in the formula was first of all rejected; this took into account the latitude of the locality. Author sees further proof for his conclusion that wave and wind currents are identical in the fact that at all wind speeds the length of the wave, as observed by Khintertan, was close to the calculated depth of friction as determined by Eckman.

Yu. M. Krylov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1014. Orlov, P. N., The influence of current carrying capacity on ice coverage (in Russian), *Trudī Novosibir. In-ta Inzh. Vod. Transp.* no. 2, 61–67, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1890.

An investigation of the carrying capacity of a current and the destruction of the ice cover consequent thereon, on rivers during the spring freshet and at the beginning of the ice stand. On the assumption of a uniform rate of flow in a wide, prismatic channel, an expression is derived for the entraining power of the current

$$\tau_d = \frac{\gamma_v v_m^2}{c_1^2}$$

where γ_v is the volume density of the water (tons/m³), and v_m the mean velocity of the flow of water in the current (m/sec); while c_1 is the Chezy coefficient for the layer of water adjacent to the underside of the ice cover. This formula is derived from analysis of the relationship of the forces in the upper part of the current, bounded by the ice cover as the upper limit, and the plane of maximum flow velocity as the lower limit. This formula is in agreement with the considerations expounded by V. M. Makkaveyev and I. M. Konovalov ["Hydraulics," Moscow-Leningrad, Rechizdat, 1940]. The entraining force is equated to the strength of the ice cover in compression, obtaining the distance (l) through which the entraining force will cause destruction of the ice cover at its

lower edge in the absence of friction on the bank

$$l = \frac{h_l [\sigma]_c C_1^2}{\gamma v V_m^2}$$

where h_l = thickness of the ice cover (metres), $[\sigma]_c$ limiting compression strength of the ice (t/m²). The Chezy coefficient for different values of the roughness of the lower surface of the ice cover is determined according to Manning. The thicknesses of the corresponding lengths of the ice cover calculated by the above formula are given. It is pointed out that, with allowance for friction of the ice against the bank, these lengths will be about double those shown in the table. The detachment of ice fields by the influence of the entraining force can be determined in a similar manner, but the resistance of the ice to tensile forces must be known. To some extent, the problems thus examined enable evaluation as well as explanation of a number of phenomena associated with spring and autumn break-up of the ice on rivers.

V. V. Piotrovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1015. Laikhtman, D. L., and Klyuchnikova, L. A., The influence of convection on the intensity of the thawing of snow (in Russian), *Trudi Gl. Geofiz. Observ.* no. 60 (122), 32–39, 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6843.

A solution is given of the problem for the change of the potential temperature in the layer next the earth for a steady process. On the condition of thermal balance, the quantity of thawed snow dm/dt is determined with convection of warm air and a boundary for the melting of the snow covering. To facilitate the calculations nomograms are plotted which make it possible to determine dm/dt at a given temperature of the air and relative humidity in a layer of air two meters thick. A preliminary check of the calculating formulas on the empirical material showed that with uniform cloudiness the convergence is satisfactory; with a small degree of cloudiness the calculated values are frequently less than the factual.

E. M. Dobryishman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1016. Bases of the methods of calculations for river-bed processes caused in rivers where river-training works have altered their nature (in Russian), Problems in river discharge control, Moscow, Akad. Nauk SSSR, 1956, 5–93; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5343.

The report is divided into the following sections: Introduction. I. General features met within river-bed processes. II. The effect of engineering constructions on the hydrological features of the river and the alteration of the river bed. III. Basic methods of prognosis of river-bed processes. IV. Silting of water reservoirs and calculations for the same. V. Building-up of the banks of water reservoirs by the action of wind waves. VI. Erosion of the bed of a river in the "lower water" caused by the holding back of the steady discharge by the water reservoir. VII. Distortions of river beds situated beyond hydro assemblies outside the limits of the zone of saturation by deposits. VIII. The condition of sand-banks in the region of undercutting of supports and in the "lower water" of the hydro assembly. IX. The effect of bridges on the river-bed processes and river bed distortion in the zone of bridge crossings. X. The trend of future work for the improvement of methods used in the prognosis of river-bed action.

The work is a unified record of the results achieved in the field of studies of river-bed processes, obtained in a number of scientific research organizations and higher educational institutions of the USSR, on the state of investigations in the field up to 1954. The review was compiled by a group of authors, working on the published and partially unpublished (presented in report form) data from the studies of a large circle of workers, each making a contribution to the task of analyzing the problems of river-bed processes. The main problem appears to be the generalization of the results of the methods used in the prognosis of changes in river-bed streams, produced in conditions of natural cause and effect and also because of engineering works carried out.

V. N. Goncharov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1017. Arakawa, H., Possible criteria of an explanation of the phenomenon of clear-air turbulence encountered by aircraft, *Pap. Meteorol. Geophys.* **9,** 1, 25–28, May 1958.

Investigation has shown that the clear-air turbulence encountered by aircraft appears to occur (1) below the jet isotach-max and on its north, or cyclonic, side; and (2) above the jet isotach-max and on its south, or anticyclonic, side. Through the use of two stability criteria (equations) which have been given by the present author, one might hope to arrive at an explanation for the phenomenon of clear-air turbulence (and to predict its occurrence).

From author's summary by A. S. Andes, USA

1018. Pinus, N. Z., Atmospheric turbulence commensurable with the dimensions of aeroplanes (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 3, 395–400, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6816.

The conditions are described of the development of atmospheric turbulence causing airplane bumping which is connected with its overloading. The connection between the velocity of the vertical air rupture and the overload of an airplane is expressed by the formula

$$\Delta n = \pm \rho u w c_{y\alpha} / 2H$$

where Δn is the overload in quotas g, ρ the density of the air, u the speed of flight of the airplane, w the velocity of the vertical rupture of the air, $c_{y\alpha}$ the characteristic of the dependence of the coefficient of the lifting power on the angle of attack, H the specific loading on the wing. The development of turbulence in the free atmosphere depends on the presence of gradients in the temperature field and in the field of wind velocity, characterized by Richardson's parameter

$$Ri = g(\gamma_a - \gamma)/T\beta^2,$$

where g is the acceleration of the force of gravity, T the mean temperature of the air in the layer, γ_a the adiabatic vertical gradient of temperature, γ the observed temperature gradient, β the vertical gradient of the wind's mean velocity. The special features are described of the baric field and of the thermal advection which favor the development of turbulence commensurable with the airplane's dimensions. A method for the prognosis of air turbulence is put forward.

U. Ts. Andres

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1019. Dzerdzeevskii, B. L., Problem of fluctuations of the general circulation of the atmosphere and climate (in Russian), A. I. Voeikov and modern problems in climatology, Leningrad, Gidrometeoizdat, 1956, 109–122; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5558.

The idea is advanced of the necessity to carry out simultaneous studies of the fluctuations in the climatological fields of meteorological elements and of the general (planetary) circulation of the atmosphere. To establish the characteristics of the state of the latter, typical plans are utilized—the mechanisms of elementary circulation systems (ETsM), proposed earlier by the author. The thirteen ETsMs separated out earlier are re-grouped into three

groups: (a) zonal circulation, (b) disruption of the zonal condition, (c) meridional circulation. Materials gathered for the ETsMs over 55 years (1899–1954) were analyzed and author comes to the conclusion that actual differences were found in the character of the circulation in the first and second halves of this period. In the first half the zonal circulation was weaker and got stronger to a marked degree in the second half. Author then compares the conditions of circulation over the whole of the territories in the Northern hemisphere with the trends as regards temperature and precipitations over the different regions. On the basis of this analysis author deduces agreement between the long-term course taken by these elements and the course taken by the circulation processes, and puts forward a hypothesis for the noticeable changes with time of the boundaries of climatic regions and their dependence on fluctuations of the circulation of the atmosphere.

S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1020. Churinova, M. P., An attempt at calculating the coefficient of turbulence from temperature-wind soundings (in Russian), *Trudi Gl. Geofiz. Observ.* no. 63 (125), 168–172, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 858.

A calculation is given of the coefficient of turbulence for the boundary layer according to two principally different methods. The formula of the first method is based on the balance equation of the turbulent energy and the second is obtained by integration of the equation of motion. The results of the calculations differ from each other by about 20%. A graph is presented which simplifies the calculation.

From author's summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1021. Budyko, M. I., Zubenok, L. I., and Strokina, O. A., Determination of the integral coefficient of the turbulent diffusion (in Russian), *Meteorol. i Gidrol.* no. 12, 34–35, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 859.

Authors determined the integral coefficient of diffusion from the measurements of temperature and humidity distribution, radiation balance and of the amount of heat flow to the ground. As the integral coefficient of diffusion D authors understood the corresponding multiplier in the equation for the turbulent stream of heat

$$P = \rho c_p D(\theta_w - \theta)$$

where ρc_p is the volume of specific heat of the air; θ_w the temperature of the acting surface; θ the temperature on the plane examined.

The determined value of D varies between 0.45 and 2.11 cm/sec. The mean value of D is equal to 1.02 cm/sec.

From authors' summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1022. Vasil'chenko, I. V., An approximate thermodynamical analysis of local ascending currents in the atmosphere (in Russian), *Trudi Gl. Geofiz. Observ.* no. 72, 3–18, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6828.

Author's starting point is based on the equations of motion, equation of continuity, equations of heat transfer and transfer of humidity, taking the axisymmetrical case. The convection flow is investigated in the form of a jet. The longitudinal turbulent agitation is looked upon as insignificantly small by comparison with the agitation on the vertical plane; the pressure in the flow at any point is considered to be equal to the atmospheric pressure at the same altitude. Arising from the concepts of dimensions the coefficient of turbulent exchange is taken to be proportional to the function of the current and inversely proportional to the nondimensional coordinate $\eta = r/z$. On the flow axis (at $r = 0$) the condition of the reversion to zero of the derivatives of temperature, humidity and vertical velocity with respect to r holds. Corresponding conditions are imposed on the boundaries of the jet (practically with $r \to \infty$). The solution of the problem, in the absence of agitation with the surrounding medium, (solution for "the adiabatic nucleus" of the flow) leads to the linear relation of the thermal surplus ϑ in the current to the height (with the coefficient of proportionality equal to $\gamma - \gamma_a$); the square of the vertical velocity proves to be the quadratic function of the height.

The next stage is the examination of the solution of the problem for the equilibrium conditions ($\gamma - \gamma_a = 0$) in the presence of turbulent exchange. For this case formulas are brought in for w and ϑ in dependence on r and z. In particular,

$$\vartheta = Cz^{-5/3} e^{-d\eta^2}$$

where C is the power of the thermal sources, while d is a constant. An analysis of these formulas indicates that the region with a thermal surplus has the form of a jet; the square of the vertical velocity on the axis of the stream w_m^2 is proportional to the thermal surplus on axis ϑ_m and height z. Then, approximate expressions are put forward for w_m, ϑ_m and the specific humidity κ_m on the axis of the current in conditions of equilibrium. Curves are given for the distribution of ϑ_m and w_m for different values of the parameter $\gamma - \gamma_a$. It is explained that the convection flow can exist even with $C = 0$ (that is in the absence of thermal sources). The case is specially examined of the linear decrease with height of the value $\gamma - \gamma_a$, which corresponds to the transition from transient stratification below to inversion above.

In conclusion, results obtained are used to determine the altitude of the condensation level. While doing the above, the case is investigated of the linear distribution of the temperature and of the specific humidity in the surrounding atmosphere when $\gamma > \gamma_a = 0$ passes over to the known formula by Forrelya, used for the calculations of the height of the lower boundary of clouds, terrestrial data being employed for the purpose. The formula obtained by the author makes it possible to evaluate the relation of the altitude of the condensation level to the atmospheric stratification in conditions of inequilibrium.

S. L. Pelousov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1023. Shishkin, N. S., On the conditions of development of convection in the atmosphere (in Russian), *Trudi Gl. Geofiz. Observ.* no. 47, 6–10, 1954; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6847.

In contrast to the usual hypothesis regarding the presence of the processes of ascent of the saturated and the descent of the unsaturated air, accepted in meteorology when investigating questions dealing with convection, author examines the problem from the criteria of convection in a general aspect, that is, an assumption is made of the presence of vertical motions both in the clouds and between the clouds. The conditions of development of convection in general form are recorded as

$$\sum_{i,k=1}^{4} M_k \left(\frac{\partial T_k}{\partial t} - \frac{\partial T_i}{\partial t} \right) > 0,$$

where the indices i and k characterize the humidity of the ascending or descending air with a mass M and a temperature T. Three special cases are investigated: (a) the layer contains only unsaturated air (the indices i and k assume the values of 1 and 2); (b) the layer contains only humid air (the indices i and k assume the values of 3 and 4); (c) the layer contains both saturated and unsaturated air (the indices i and k may have any arbitrary value between 1 and 4). From the investigation of the first two cases, known positions are obtained regarding the possibility of the ex-

istence of convection flows only in cases of unstable stratification of the atmosphere $\gamma > \gamma_c$ or $\gamma > \gamma_B$. By examination of the third case a determination was made for the critical values of temperature gradients during regular convection circulation. In the case of circulation with active ascending flow with the clouds correctly disposed in the form of scimitars

$$\gamma = \frac{\gamma_B + 0.7\,\gamma_c}{1.7}$$

and, in the case of cloudiness being present with round open spaces between the clouds—with circulation with active descending flow

$$\gamma = \frac{\gamma_B + 1.44\,\gamma_c}{2.4}.$$

For the development of this or that form of circulation, in addition, the real value has the character of a change of temperature gradient with altitude.

I. S. Pavlova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1024. Dyubyuk, A. F., Dependence of wind and vertical velocity on the pressure field when taking into account the nonlinear terms of acceleration and internal friction (in Russian), *Trudi Leningrad Gidrometeorol. In-ta* no. 5/6, 312–320, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5565.

A system of equations is solved

$$u_t + uu_x + vu_y - vu_{zz} + lv = -P_x$$
$$v_t + uv_x + vv_y - vv_{zz} - lu = -P_y \qquad [1]$$

describing the distribution of the wind in the boundary layer of the atmosphere at a given barometric gradient, with the coefficient of turbulence ν a constant, and disregarding in the left portions of [1] terms wu_z and wv_z, respectively. Here u and v are components of the velocity along horizontal coordinates x and y; z is the height, t the time, w the vertical component of the velocity, l is Coriolis' parameter; $P_x = p_x/\rho$, $P_y = p_y/\rho$, p is the pressure, ρ is the density; the index shows the result of differentiation by the corresponding argument. The equations are recorded in the left system of coordinates, the reverse of the system ordinarily applied in dynamic meteorology. A method is proposed for the solving of system [1], namely, the determination in it of u and v, which the author states, formally, as a search for a solution in the form of a series by the small parameter, which then is deemed to be equal to 1. Actually this method is equivalent to the method of successive approximations: in the first approximation the convective derivatives in the left portions of Eq. [1] are disregarded; in the second approximation these derivatives are taken into account in the form of expressions found from the first approximation, and so on. The solution of each approximation is found in the form of integrals by variables corresponding to height and time. For the stationary problem ($u_t = v_t = 0$) when P_y and P_x are independent of the height (that is, absence of a thermal wind) the solution for each approximation is obtained in the closed form. For the last case numerical calculations are given in which only the first two approximations are taken into account. The known solutions by Ekman-Okerblom are described by the first approximation. By addition of the second approximation, account is taken in particular of the influence of the comparison or ratefaction of the isobars across the flow on the vertical profile of the wind. In other words, if the isobars get denser to the right of the flow then the wind deflects to a lesser extent from the isobars, and vice versa. On the basis of the solution obtained and with the aid of the equation of continuity formulae are derived for the vertical components of the velocity. The influence is investigated of the compression of the isobars on the vertical profile of that component. In all these calculations only the influence of the compression or rarifying of the isobars is considered, and the influence of their getting closer or farther apart is not taken into account. Some concepts are given on the convergence of the proposed approximate method.

L. S. Gandin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Friction, Lubrication and Wear

(See also Revs. 672, 709, 728, 891)

1025. Sciulli, E. B., and Robinson, G. M., A study of the effect of wear particles and adhesive wear at high contact pressure, *ASLE Trans.* **1**, 2, 312–318, Oct. 1958.

Cobalt-based alloys and stainless steels were tested for wear rate by rubbing together at pressures ranging from 20,000 to 300,000 psi at speeds of 9.35 or 93.5 in. per minute in an environment of demineralized water. The test piece diameter was 0.06 to 0.08 in.

Wear-rate curves are presented which reveal no apparent discontinuity as the contact stress passes through one third of the hardness as predicted by Burwell, neither was any region observed where the wear factor was independent of contact stress as found by Burwell in the region below this value.

Results are presented in the form of linear plots of wear factor against contact stress and an "apparent critical stress" is derived from the intercept of the tangents to the curves in the high and low stress regions. Evidence is, however, provided that an exponential relationship holds, and a surprising statement is made that there was neither time nor funds available to substantiate this.

On resuming a test after interruption, wear rate and friction were found to be lower than before; this was attributed to the possible formation of contaminating films at the wear surfaces. Other tests were made with annular rings which prevented the escape of debris. Escape routes were then provided by cutting radial slots which led to a considerable reduction in wear.

Reviewer regrets the inability of the authors to complete the analysis of their results because the investigation showed promise of results of basic value.

F. T. Barwell, England

1026. Steijn, R. P., An investigation of dry adhesive wear, *ASME Trans.* **81**D (*J. Basic Engng.*), 1, 56–66, Mar. 1959.

Sliding-motion experiments under unlubricated conditions have been carried out on various metals, and the results are discussed in terms of the simple wear theory advanced by Archard.

Oxide-film formation has been studied by electrical contact-resistance measurements made in conjucntion with wear tests. The effects on the wear rate and basic wear formula are discussed. For the ring apparatus, a modified expression for the wear formula is suggested to incorporate surface oxidation.

Although it was found that the sliding of a soft material on a hard material follows simple wear rules, discrepancies are reported for the wear of brass against brass. In these experiments, the wear rate is affected by the geometry of the apparent area of contact.

From author's summary

1027. Haussler, F. W., and Wonka, A., Calculation of the stick-slip process (in German), *Maschinenbautechnik* **8**, 1, 45–53, Jan. 1959.

In this calculation of the important stick-slip phenomena the known Stribect friction-curve is replaced by two linear functions

in the relative velocity of the sliding bodies. As the analysis is not carried out in the common form of a phase-plane-treatment (see for example: J. J. Stoker, "Nonlinear vibrations" or H. Kauderer, "Nicthlineare Mechanik") no general conclusions about the behavior of such systems can be given.

The equations of motion—holding for the different ranges of sliding velocity—are solved stepwise and the solutions for three examples of engineering significance are presented in graphical form. A. Slibar, Germany

1028. Mason, W. P., Adhesion between metals and its effect on fixed sliding contacts, *ASLE Trans.* **2,** 1, 39–49, Apr. 1959.

Recent studies of adhesion between metals measured as a function of pressure, temperature and time have resulted in a quantitative understanding of the process. Creep causes the spaces between the point contacts to be filled in and molecular seizure occurs.

Recent work by O. L. Anderson has shown that seizure can occur between two sets of metals if a twist is superposed on a compression. By this technique, the area of contact is increased over that resulting from compression alone, and a large enough area of contact results so that the adhesive stresses overbalance the elastic stresses which tend to disrupt the adhesive bond. Hence seizure occurs. By studying the coefficient of adhesion as a function of the applied stress, Amonton's law of friction has been verified from the adhesion side, thus confirming the Bowden-Tabor theory of stick-slip friction.

Adhesion between metals due to compression, occurring over a finite time, is essential for such connections as the solderless wrapped connection and is important for contacts left under pressure in the same position for a length of time as in printed circuit type connections. Adhesion between metals caused by both compression and shear is the cause for mechanical seizure, plowing and wear experienced in sliding contacts. Direct force measurements have shown the nature of the slip-stick process.

From author's summary

1029. Towle, A., Problems encountered in the lubrication of small two-stroke petrol engines, Instn. Mech. Engrs., Auto. Div., Prepr., 16 pp., 1958.

This paper details part of a very extensive road and bench test program to determine the influence of various factors governing the lubrication of small two-stroke petrol engines.

It is shown that while most engines can be lubricated by oils ranging from S.A.E. 10W to S.A.E. 50 viscosity grade, the most satisfactory oil depends largely upon the design of the particular engine and the operating conditions.

When using straight or treated oils, the most common factor limiting the life between overhauls is port blocking, but correct selection of base oil and additive enables milages of over 3000 to be covered without attention to the ports, even on the smallest motorized cycle units and this usually represents over a year's use. On larger engines, milages of over 10,000 should be easily possible.

The most irritating trouble is undoubtedly connected with the sparking plug, and usually takes the form of whiskering, which can be virtually eliminated by the use of special additives and can be minimized in any case by careful maintenance of both carburation and ignition systems.

During the whole series of road tests, on both straight and treated oils, no failures of either connecting-rod, big-end, or main bearings have been experienced which could be attributed either to corrosion, lack of oiliness of the lubricant, or even lack of any lubricant. Author feels that this is largely due to the care taken in mixing the lubricant and the fuel under laboratory conditions.

Service complaints of rapid wear of main and connecting-rod bearings are usually bound up with the absence of any lubricant at the bearing, either through inefficient mixing of the fuel and lubricant or by the designer shrouding the bearing in question. There are, however, exceptional critical conditions of operation on short journeys followed by standing at low crankcase temperatures, which in some designs can produce corrosion in exceptionally short milages. The remedy is to maintain the crankcase at as high a temperature as practicable both during standing and running.

Whatever oil is chosen must be largely a compromise between conflicting requirements of long life without port blocking and protection against piston seizure under adverse conditions. S.A.E. 10W oils give rise to least port blocking, but fail to provide protection against piston seizure under the worst conditions and, in addition, can give rise to rapid wear of the piston gudgeon-pin bosses. Conversely, high V.I. S.A.E. 50 oils, while liable to promote port blocking, give the best possible protection against piston seizure. As a compromise, suitable treated medium V. I. S.A.E. 30 oils have the best all-round properties.

From author's summary

1030. Eary, D. F., Determining effectiveness of drawing lubricants, *Tool Engr.* **43,** 2, 83–90, Aug. 1959.

Means are available to the experimenter to simplify techniques and make results of experiments more meaningful. One of these is statistical analysis. The author illustrates how statistics can be used in tooling experiments by application to determine procedure and evaluate results of an actual experiment.

From author's summary

1031. Golothan, D. W., Influence of the lubricating oil on some operating problems of the two-stroke gasoline engine, Instn. Mech. Engrs., Auto. Div., Prepr., 12 pp., 1958.

The small two-stroke gasoline engine has recently become very popular owing to improvements in design and performance, and because of its general cheapness and simplicity of construction. Most of these engines are lubricated by the 'Petroil' system, that is, the oil and gasoline are mixed together before they are put into the fuel tank. This system, together with the characteristic design features of the engine, leads to various problems, the commonest of which are sparking plug fouling, exhaust port blocking, piston seizure, bearing corrosion, and general piston deposits.

Various engine tests were used to study these problems, and it was found that their overall solution demanded conflicting properties of the lubricating oil. By a suitable compromise, however, it is possible to formulate an oil which gives satisfactory results in all aspects of performance.

From author's summary

1032. Tao, L. N., The hydrodynamic lubrication of sector thrust bearings, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 406–416.

Exact solution of this important lubrication problem is derived and shown to involve Bessel functions of first and second kinds and Lommel (or Struve) functions of real arguments. Numerical computation of specific problems is thus possible via tabulated functions. Previous solutions [Muskat, et al. 1940; Wood, 1949; and AMR **6**(1953), Revs. 1917, 2967, **10**(1957), Rev. 1824, **11**(1958), Revs. 4819, 2890] have involved approximations of one kind or another (such as use of numerical methods with finite-meshed grids, or simplified pressure distribution functions). Example calculations for the 45-degree "square" sector are indicated and the results for the load capacity and friction moment coefficients compared with those of previous investigators; agreement is within a few per cent. J. M. Robertson, USA

1033. Kunin, I. A., Hydrodynamic theory for the lubrication of a thrust bearing (in Russian), *Izv. Vost. Fil. Akad. Nauk SSSR* no. 4/5, 128–137, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7725.

The solution of the problem of the three-dimensional flow of a lubricant of variable viscosity in a thrust bearing is set forth in abbreviated form. The Reynolds equation and an approximate equation for the heat balance, in which the heat taken off through the thrust pin wall and thrust bearing segment are approximately allowed for by a coefficient, are examined. When solving the Reynolds equation, author sets himself a certain relationship between the viscosity of the lubricant and the angle of flow in the direction of rotation of the segment.

Two methods of solving the Reynolds equation are possible. The first method consists of the transfer to new variables, in which the equation is not altered and the viscosity is little dependent on the angle. Assuming the viscosity to be constant, a Poisson equation is obtained whose solution presents no difficulties. The expression found for the distribution of pressure is substituted in the thermal balance equation, from which the value of the parameter used in the relationship between viscosity and angle is determined. In the second method it is assumed that the relationship of the viscosity of the lubricant to the angle is expressed through a harmonic function. A Poisson equation is also obtained for the product of this function and the pressure. This method of solution is simpler (but less general) than the first, and is recommended for thrust bearing calculations. A procedure is described for making the calculations for thrust bearings, using graphs, in the case where the ratio between outer and inner thrust bearing radii is 1.57. A. I. Golubev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1034. Comolet, R., Flow of fluid between two parallel planes; contribution to the study of air lubricated bearings (in French), *Publ. Sci. Tech. Min. Air, France,* no. 334, 68 pp. + 18 tables, 1957.

1035. Raimondi, A. A., A theoretical study of the effect of offset loads on the performance of a 120° partial journal bearing, *ASLE Trans.* **2,** 1, 147–157, Apr. 1959.

This is an extension of previous work carried out by the author and J. Boyd, *ASLE Trans.* **1,** 159–209, 1958, The influence of load position on film thickness, eccentricity, journal position, friction, flow, temperature rise and maximum film pressure is found by a numerical solution of the Reynolds equation carried out on a digital computer. It is assumed that viscosity is constant and the L/D ratio is unity. W. P. Jensen, USA

1036. Brix, V. H., Shaft stability in gas film bearings, *Engineering* **187,** 4848, 178–182, Feb. 1959.

Letters to the Editor

1037. Re: AMR **11**(1958), Rev. 3621: **Rao, D. M., On the design of uniform flow subsonic nozzles,** *J. Aero. Soc. India* **9,** 4, 51–55, Nov. 1957.

Reviewer mentions an assumption (equality of the displacement thickness growth rates in constant area and constant Mach number ducts) which does not occur in the paper, and further imagines the 'inaccuracy of this assumption' to be 'recognized by the author.'

The displacement thickness growth rate ($d\delta^*/dx$) is obtained from low-speed tests on a constant area nozzle in presence of small Mach number gradients. From these values, the required value of $d\delta^*/dx$ for zero Mach number gradient is obtained by extrapolation. The only assumption involved is the linear variation of the Mach number gradient with Mach number for small values of Mach number, which is borne out by experiments (Fig. 3 of the paper).

The proposed method is accurate enough to yield a value of ($d\delta^*/dx$ (0.00267) which is almost identical with the calculated value for a flat plate turbulent boundary layer (0.00265), as shown in the paper. D. M. Rao, India

1038. Re: AMR **12**(1959), Rev. 5801: **Muller, E.-A., and Matschat, K., On the production of noise from decaying homogeneous isotropic turbulence** (in German) *Z. Flugwiss.* **6,** 6, 161–170, June 1958.

Sixth line from bottom should read: "... = function of Reynolds number..." instead of: "... = fraction of Reynolds number...". The editors regret this error.

1039. Re: AMR **12**(1959), Rev. 4915: **Ziegler, H., A modification of Prager's hardening rule,** *Quart. Appl. Math.* **17,** 1, 55–65, Apr. 1959.

I. In his review of the above-mentioned article, Dr. Alexander writes: "Author maintains that for certain states of stress... Prager's hardening rule requires that the yield surface must deform. He claims that his own hardening rule does not suffer from this disadvantage. After a general discussion in tensor mathematics and comparison between the two rules he concludes that his own rule is inferior to Prager's from the physical point of view, but easier to handle in certain classes of application."

I believe to have proved, in collaboration with R. T. Shield [AMR **12**(1959), Rev. 2824], that Prager's hardening rule, postulating a rigid translation of the yield surface in 9-space σ_{ij} in the direction of its outward normal, does not hold in this simple form in certain subspaces appropriate for the treatment of special states of stress. In the article reviewed by Dr. Alexander I tried to show that Prager's rule can be modified in such a way that its geometrical interpretation is the same in any subspace as in 9-space. Most of what reviewer refers to as "a general discussion in tensor mathematics," i.e., the actual content of my paper, is a proof of this invariance.

These proofs are either correct or incorrect. If reviewer found them incorrect, I would have welcomed a precise statement to this effect.

2. Dr. Alexander is concerned by author's statement: "At the present stage of research, it seems hopeless to expect a decision by experiment between the hardening rules confronted here. Comparison must be based, therefore, on purely theoretical reasoning." I agree with him that the whole purpose of applied mathematics is to describe physical phenomena. It may be allowed, though, to quote what Prager states in connection with his own rule ["An introduction to plasticity," Addison Wesley, Reading, Mass., 1959, p. 10]: "The theory of plasticity on which this model is based can therefore be expected to give, at best, a highly simplified approximate description of the actual behavior of plastic solids. The comparison of experimental results with the predictions of the theory may well reveal that the theory furnishes only the general traits and not the detailed features of actual plastic behavior. This has not always been appreciated by experimentalists, who have unduly criticized the theory."

It seems obvious to me that these remarks also hold for an approach clearly labelled as a modification of Prager's rule.

H. Ziegler, Switzerland

Books Received for Review

AGTE, C., KOHLERMANN, R., and HEYMEL, E., Schneideramik Herstellung, Eigenschaften und Anwendung, Berlin, Akademie-Verlag GMBH, 1959, xi + 203 pp. DM 19.50.

ANTONI, C. P., and ANTONIU, I. S., Comportarea masinilor electrice la unda de soc, Monografii de teknica IV, Bucuresti, Editura Academiei Republicii Populare Romine, 1957, 200 pp. Lei 12.50.

BUIMOVICI, D., Studiul citorva proprietati ale lignitilor din R. P. R. si ale semicocsului lor, Bucuresti, Editura Academiei Republicii Populare Romine, 1955, 110 pp. Lei 3.90. (Paperbound)

CASACCI, S., and BOSC, J., Calcul a la flexion des coques coniques, Paris, Dunod, 1959, xiv + 161 pp. 1800 F. (Paperbound)

CHACE, W. G., and MOORE, H. K., edited by, Exploding wires, New York, Plenum Press, Inc., 1959, ii + 373 pp. $9.50.

DASEK, V., Statika ramovych konstrukci, Praha, Ceskoslovenska Akademie VED, 1959, 549 pp. Kcs 43.

DAWSON, J. K., and LONG, G., Chemistry of nuclear power, New York, Philosophical Library, Inc., 1959, vi + 208 pp. $10.

DEJUHASZ, K. J., SCICCHITANO, E. A., et al, Spray literature abstracts, New York, American Society of Mechanical Engineers, 1959, viii + 383 pp.

DRESDEN, M., Kinetic theory applied to hydrodynamics (Colloquium lectures in Pure and Applied Science no. 1, June 1956), Dallas, Texas, Magnolia Petroleum Co., 1957, 127 pp.

DUMER, G. W. A., Modern electronic components, New York, Philosophical Library, Inc., 1959, viii + 472 pp. $15.

EYRING, H., Statistical dynamics (Colloquium lectures in Pure and Applied Science no. 3, June 1957), Dallas, Texas, Magnolia Petroleum Co., 1958, 195 pp.

FLUGGE, S., edited by, Handbuch der Physik, Band 3/2, Prinzipien der Thermodynamik und Statistik, Berlin, Springer-Verlag, 1959, vii + 678 pp. DM 96.

FRITSCH, J., TREMMEL, E., and WOGRIN, A., Der VI (Sixth) Kongress der Internationalen Talsperrenkommission (Schriftenreihe des Osterreichischen Wasserwirtschaftsverbandes Heft 39), Wien, Springer-Verlag, 1959, 56 pp. $1.80. (Paperbound)

GRAF, U., and HENNING, H.-J., Formeln und Tabellen der mathematischen Statistik, Berlin, Springer-Verlag, 1958, vii + 104 pp. DM 12.60.

HINZE, J. O., Turbulence, New York, McGraw-Hill Book Co., Inc., 1959, ix + 586 pp. $15.

KUETHE, A. M., and SCHETZER, J. D., Foundations of aerodynamics, 2nd ed., New York, John Wiley & Sons, Inc., 1959, xiv + 446 pp. $11.75.

KUNTZMANN, J., Methodes numeriques, interpolation derivees, Paris, Dunod, 1959, xvi + 252 pp. 3600 F.

LIN, C. C., Turbulent flows and heat transfer (High speed aerodynamics and jet propulsion, Vol. V) Princeton, New Jersey, Princeton University Press, 1959, xv + 549 pp. $15.

MARINESCU, M., and APOSTOL, P., Difuzoare electrodinamice, Monografii de tehnica II, Bucuresti, Editura Academiei Republicii Populare Romine, 1957, 199 pp. Lei 9.

ONIASHVILI, O. D., Certain dynamic problems of the theory of shells (Translation from the Russian 1957 edition by Morris D. Friedman, Inc.), West Newton, Mass., Morris D. Friedman, Inc., 1959, iii + 178 pp. (Paperbound)

ROTTER, E., Anwendung von Spritzbeton (Schriftenreihe des Osterreichischen Wasserwirtschaftsverbandes Heft 35), Wien, Springer-Verlag, 1958, 44 pp. $1.65. (Paperbound)

SAPHIER, I. I., Recuperarea pierderilor de caldura din industrie, Bucuresti, Editura Academiei Republicii Populare Romine, 1953, 104 pp. Lei 4.80. (Paperbound)

SEIFERT, H., edited by, Space technology, New York, John Wiley & Sons, Inc., 1959, xvi + 1124 pp. + appendix + index. $22.50.

SHAMES, I. H., Engineering mechanics; statics, New York, Prentice-Hall, Inc., 1959, xxxi + 272 pp. $6.35 ($4.75 text edition for classroom).

STÜSSI, F., Entwurf und Berechnung von Stahlbauten, Erster Band, Grundlagen des Stahlbaues, Berlin, Springer-Verlag, 1958, ix + 577 pp. DM 55.50.

TAYLOR, H. F., FLEMINGS, M. C., and WULFF, J., Foundry engineering, New York, John Wiley & Sons, Inc., 1959, vi + 407 pp. $9.75.

TAYLOR, J., Solid propellent and exothermic compositions, New York, Interscience Publishers, 1959, 153 pp. $4.25.

TOCH, A., and SCHNEIDER, G. R., edited by, Proceedings of the Seventh Hydraulics Conference June 16–18, 1958, Iowa Institute of Hydraulic Research, 1959, Iowa City, Iowa; State University of Iowa, 305 pp. (Paperbound)

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